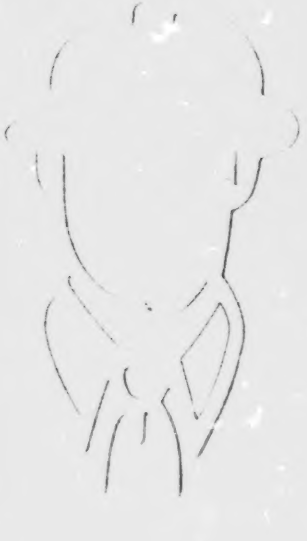
the cambrian engineering group limited



the cambrian engineering group limited

COPY NO. 4

R. ALAN HOAR

RA Hoar
March 1985

DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

PHASE III SYSTEM DESIGN

VOLUME 1 - REPORT

D.S.S. Contract Serial No. 0SQ83-00287

D.S.S. File Number 03SQ23440-3-9048

Project No. B3333

February, 1985

the cambrian engineering group limited

4815 - 78 Avenue S.E.,
CALGARY, Alberta,
T2C 2Y9
Phone (403)236-3553
Telex 038-25872

March 15, 1985

Dr. A.I.A. Salama,
Canmet Coal Research Lab,
101 Oilpatch Drive,
DEVON, Alberta

Dear Sirs:

Re: Development of a Froth
Flotation Control System
Our Project B3333

Enclosed is the Phase III Report, "System Design". This is the Final Report.

We found this work to be challenging and interesting and look forward to the purchase, installation, and commissioning.

Yours very truly,

THE CAMBRIAN ENGINEERING GROUP LIMITED

R. Alan Hoar

R. Alan Hoar, P. Eng.,
Project Engineer

RAH/jr

Encl.

TABLE OF CONTENTS

PHASE III REPORT
DETAILED DESIGN

(i) EXECUTIVE SUMMARY (English and French)

1.0 INTRODUCTION

  1.1 General

  1.2 Phase I Review

  1.3 Phase II Review

2.0 DETAILED DESIGN DRAWINGS

  2.1 Process Flow Sheet and Discussion

  2.2 Piping and Instrument Diagram and Discussion

    2.2.1 General

  2.3 Piping Drawings

    2.3.1 Drawing for Tailings Ash Analyzer
    2.3.2 Drawing for Feed Ash Analyzer
    2.3.3 Drawing for Air Piping and Reagent Tanks/Pump

  2.4 Electrical Drawings

3.0 INSTRUMENT SPECIFICATIONS

4.0 IMPELLER SPEED CONTROL

5.0 CONTROLLERS AND OPERATOR INTERFACE

  5.1 Control System Architecture

  5.2 Discussion of Systems

6.0 PROGRAMS

7.0 COST ESTIMATE

  7.2 Phased Expenditure

8.0 APPENDIX

APPENDIX INDEX

1. Specification for Distributed Control System
2. Reagent Pumps Data
3. Sala Pump Data
4. Speed Controllers Data
5. Torque Sensor Data
6. MICON Budget Quote
7. Business Cards
8. Ash Analyzer
9. Basis for Phase III Design
10. Originally Planned System Architecture
11. Program Listings and Sample Results
12. Full Size Drawing Prints

EXECUTIVE SUMMARY

The froth flotation process is used to obtain part of the clean coal at many coal wash plants in Canada. Typically the froth flotation process is not controlled as well as it could be. Few measurements are taken; adjustments to the process are made infrequently and are based on the operators' observations or based on lab results.

This work was: to investigate and review what others have done by means of a literature search and review; to recommend optional control strategies which could be applied at an existing froth flotation process; and finally to do a system design for purchase and installation of a control system at this location. The existing froth flotation process is located at the Coal Research Center in Devon, Alberta and the flotation process is part of the Canmet Coal Research Lab Pilot Plant.

Phase I of this work was a literature search and review. Phase I identified these variables as being significant in the froth flotation process:

Disturbances to the Process

Coal rank and type
Degree of coal oxidation
Feed size distribution
Presence of clay slimes
Water composition (pH, hardness)
Feedrate by volume and mass

Measured Variables

Coal composition (ash)
Volume flowrates
Pulp density
Pulp level
Power input to pulp impellers

Manipulated Variables

Reagent addition rate (frother, fuel oil)
Reagent addition points
Aeration rate
Impeller speed
Pulp level
Conditioning time
Froth sprinkling (if used)
Coarse/fine split

All the variables are related and all the manipulated variables have some effect on the process.

Phase II work addressed the question, 'which variables should be measured and which should be manipulated in order to best control the process?'

Phase II became more specifically directed to finding the best strategy for the Coal Research lab pilot plant. Several strategies were presented. The first requirement is to measure and control the feed to the flotation process. For the pilot plant the proposed method is to

(1) measure and control total slurry feed volume;
(2) measure specific gravity of the slurry, calculate the percent solids, and add dilution water to control the percent solids of the feed slurry. Thus a value of mass flow (kg/min) of solids feeding to flotation is determined and held relatively constant. This solids feed rate can be used to feed forward and adjust the amounts of reagent added. Most commercial wash plants would stop at this level of control. Stabilizing the feed as much as possible and using the measured values of the feed to control reagents is the control strategy which should be used first, and without this strategy more complex strategies are not likely to succeed.

EXECUTIVE SUMMARY

After review of the Phase II report, Canmet Coal Research Lab requested that Phase III be a system design including the stabilizing control just mentioned plus

- measure slurry ash in feed stream;
- measure pH;
- calculate mass flow of solids (coal and ash) in the feed and mass flow of coal in the feed;
- use mass flow of coal to vary the reagent addition rate;
- measure and control pulp level;
- measure flow, SG and ash of the tailings;
- by a mass balance calculation determine the product recovery and product grade;
- measure air addition, impeller power and control the specific power to the impellers by providing variable speed impellers.

The design includes drawings of the process, drawings of the instrumentation, specification of all the instruments, drawings of the installation of ash analyzers, drawing of the electrical installation, specification of a Distributed Control/Shared Display system for process control, and a cost estimate. Distributed Control Systems offered by several manufacturers are compared. There are large differences in cost and in features of various systems. Coal Research Lab people will have to closely examine their requirements in order to make the best selection. The Phase III report recommends one system based on a perception of the requirements of the Coal Research Lab pilot plant.

Implementation of the designed froth flotation control strategy can directly follow this work. The cost estimate shows the expenditure required for the full system. The estimated cost is $528,000. Of this amount over $200,000 (38% of cost) is for two ash analyzers for feed and tailings.

RÉSUMÉ

Le procédé de flottation par moussage sert à obtenir une partie du charbon épuré dans de nombreuses installations de lavage du charbon au Canada. Ce procédé n'est généralement pas aussi bien contrôlé qu'il pourrait l'être. Les mesures prises sont peu nombreuses, et les réglages peu fréquents, faisant suite aux observations de l'opérateur ou aux résultats des analyses en laboratoire.

La présente étude consistait à rechercher et à analyser la documentation existant sur le sujet; à recommander un choix de mesures de contrôle pouvant être appliquées à une installation existante de flottation par moussage; et finalement à concevoir un système permettant l'acquisition et la mise en place d'un dispositif de contrôle à cet endroit. Il s'agit du Centre de recherche sur le charbon se trouvant à Devon, en Alberta, et le système de flottation fait partie de l'installation-pilote du laboratoire de recherche sur le charbon de CANMET.

La phase I de l'étude consistait à procéder à une recherche et à une analyse de la documentation. Il s'agissait d'identifier les variables considérées comme importantes dans le procédé de flottation par moussage:

Problèmes au niveau du procédé

Qualité et type de charbon
Degré d'oxydation du charbon
Répartition des calibres d'alimentation
Présence de boues argileuses
Composition de l'eau (pH, dureté)
Vitesse d'alimentation en volume et en masse

RÉSUMÉ

Variables mesurées

- Composition du charbon (cendre)
- Débits volumiques
- Masse volumique de la pulpe
- Niveau de pulpe
- Alimentation électrique des turbines

Variables manipulées

- Taux d'addition des réactifs (agent de moussage, gazole)
- Points d'addition des réactifs
- Taux d'aération
- Vitesse des turbines
- Niveau de pulpe
- Temps de conditionnement
- Aspersion de mousse (le cas échéant)
- Division en particules grossières/fines

Toutes les variables sont reliées, et toutes les variables manipulées ont un effet sur le procédé.

La Phase II de l'étude consistait à essayer de répondre à la question: «Quelles variables devraient être mesurées et lesquelles devraient être manipulées afin d'obtenir le meilleur contrôle du procédé?».

La Phase II a consisté plus particulièrement à trouver la meilleure stratégie à appliquer à l'installation-pilote du Laboratoire de recherche sur le charbon. Plusieurs solutions ont été présentées. Il faut tout d'abord mesurer et contrôler l'alimentation du dispositif de flottation. La méthode proposée pour l'installation-pilote est la suivante:

1) mesurer et contrôler le volume d'alimentation total en coulis;
2) mesurer la densité du coulis, calculer le pourcentage des éléments solides et ajouter l'eau de dilution pour ajuster ce pourcentage. On établit ainsi un débit massique (kg/min) des solides vers le dispositif de flottation, et on le maintient relativement constant. Ce débit peut servir à l'alimentation et au réglage de l'addition des réactifs. La plupart des installations commerciales s'arrêteraient à ce niveau de contrôle. La stabilisation de l'alimentation dans la mesure du possible et l'utilisation des valeurs mesurées de cette alimentation afin de contrôler les réactifs constitue la méthode de contrôle qui devrait d'abord être utilisée, car sans appliquer cette solution, il ne sera probablement pas possible d'en établir de plus complexes.

Après avoir étudié le rapport de la Phase II, le Laboratoire de recherche sur le charbon de Canmet a demandé que la Phase III consiste à concevoir un système comportant le contrôle de la stabilisation indiquée ci-dessus, ainsi que les étapes suivantes:

- mesurer les cendres de coulis de l'alimentation;
- mesurer le pH;
- calculer l'écoulement massique des solides (charbon et cendre) et celui du charbon seul de l'alimentation;
- utiliser l'écoulement massique du charbon pour faire varier le taux d'addition des réactifs;
- mesurer et contrôler le niveau de pulpe;

- mesurer l'écoulement, la présence de gaz et les cendres dans les résidus;
- déterminer, par un calcul du bilan massique, la quantité et la qualité du produit obtenu;
- mesurer l'addition d'air, la puissance de la turbine et contrôler cette puissance par l'utilisation de turbines à vitesse variable.

La conception comprend les plans s'appliquant au procédé, les plans du dispositif, les normes techniques de tous les instruments, les plans de l'installation des analyseurs de cendres, ceux de l'installation électrique, les spécifications relatives à un système de commande distribuée/affichage partagé pour le contrôle des opérations, ainsi qu'une évaluation des coûts. Les systèmes de commande distribuée mis sur le marché par divers fabricants sont alors comparés. Ils présentent de grandes différences de prix et de caractéristiques. Le personnel du Laboratoire de recherche sur le charbon devra examiner de près les besoins correspondants afin de faire le meilleur choix. Le rapport de la Phase III recommande l'utilisation d'un système en fonction des exigences envisagées pour l'installation-pilote du Laboratoire.

La mise en oeuvre du contrôle de la flottation par moussage ainsi conçu peut se faire immédiatement. Le coût prévu pour l'ensemble du système est de 528 000 $, dont 200 000 $ (38 % du total) pour les deux analyseurs de cendres pour l'alimentation et les résidus.

1.0 INTRODUCTION

1.1 General

The Canmet Coal Research Lab wishes to install a modern and advanced control system on the Froth Flotation Section of their Coal Washing Pilot Plant located at Devon, Alberta.

A contract, in three phases, was awarded to Cambrian Engineering. Phase I was to study available literature and examine the experiences of others who have studied the control of froth flotation processes. After completion of Phase I, approval was received to proceed with Phase II.

Phase II, "Preparation of Alternatives" was to propose feasible process control alternatives for consideration by the Coal Research Lab. Phase II was completed in September 1984. Approval to proceed with Phase III was given November 1, 1985 and the work was to be delivered by March 15, 1985. This report, including appendices and enclosures, is the Phase III work.

1.2 Phase I Review

Phase I of this project was titled State of the Art. Most of the work was to find and obtain copies of papers and articles which were on the general subjects of:

- Flotation Simulation
- Flotation Control
- Ash Measurements in Coal

Copies of the computer literature search printouts and copies of all articles obtained were given to Canmet. A report summarizing the findings was prepared. Following is the table of contents of that report.

1.0 INTRODUCTION

TABLE OF CONTENTS PHASE I REPORT

1.0 EXECUTIVE SUMMARY

2.0 MECHANISM AND PRACTISE OF COAL FLOTATION

- 2.1 Mechanism of Flotation
- 2.2 Flotation Reagents
- 2.3 Flotation Plant Feed
- 2.4 Flotation Machines
- 2.5 Process Combinations
- 2.6 References

3.0 FLOTATION VARIABLES

- 3.1 Disturbances to the Process
- 3.2 Measured Variables
- 3.3 Manipulated Variables
- 3.4 Controlled Variables
- 3.5 Variables Discussion

4.0 FLOTATION CONTROL

- 4.1 General Aspects of Flotation Control
- 4.2 Coal Flotation Control Strategies
- 4.3 Classification of the Control Strategies
- 4.4 Promising Control Strategies
- 4.5 References

5.0 APPENDICES

- 5.1 Appendix A
  Flotation Machines by Peter Young.

The Phase I report was delivered in April, 1984.

1.0 INTRODUCTION

1.3 Phase II Review

Phase II of this project was entitled Process Control Alternatives. The intent of this phase was to present various strategies which would be feasible to implement at the Coal Research Lab Pilot Plant at Devon. From these alternatives a selection was to be made by the Coal Research Lab people. This selection would form the basis of detailed design.

Our Phase II report presented alternatives ranging from quite simple to quite complex. Our recommendation was to design and install a fairly simple system, consisting of measuring and control devices to regulate the volumetric and mass flowrates of feed to the froth flotation cells and provide feed forward control to vary reagent addition rates. Phase II Report, Section 4 explains our recommendation more fully.

The Coal Research Lab did not agree with this recommendation and asked that Phase III consist of detailed design of the instrumentation and control system for a more complex Process Control Alternative. A letter of October 19th, 1984 and a meeting of October 28th state the requirements of the Phase III design. These documents are reproduced in the Appendix.

Perhaps the logic of the Coal Research Lab people was to ask for design encompassing the largest scope in order to get the most value for dollars spent on design. This is an understandable and perhaps correct objective.

1.0 INTRODUCTION

The Table of Contents of the Phase II Report is reproduced here for reference.

TABLE OF CONTENTS PHASE II REPORT

1.0 INTRODUCTION

2.0 LEVEL I CONTROL SYSTEMS
- 2.1 Flotation Variables
- 2.2 Feed Control and Measurement Options
- 2.3 pH Control
- 2.4 Specific Power Input
- 2.5 Level Control
- 2.6 Froth Concentrate and Tailings Measurement
- 2.7 Ash Measurements

3.0 LEVEL II AND LEVEL III CONTROL STRATEGIES
- 3.1 Basic Control System Review
- 3.2 Level II Supervisory Control
- 3.3 Level III Multivariable Optimizing Computer Control

4.0 SELECTION OF ALTERNATIVE

5.0 APPENDICES
- Appendix A Power Input Correlation
- Appendix B Regulatory Loop Controller
- Appendix C Supervisory Control Model
- Appendix D Stochastic State Space Models
- Appendix E Extended Kalman Filter
- Appendix F The Simplest Model
- Appendix G Simple Phenomenological Model of the Flotation Cell
- Appendix A Rate Constants in Flotation Phenomena

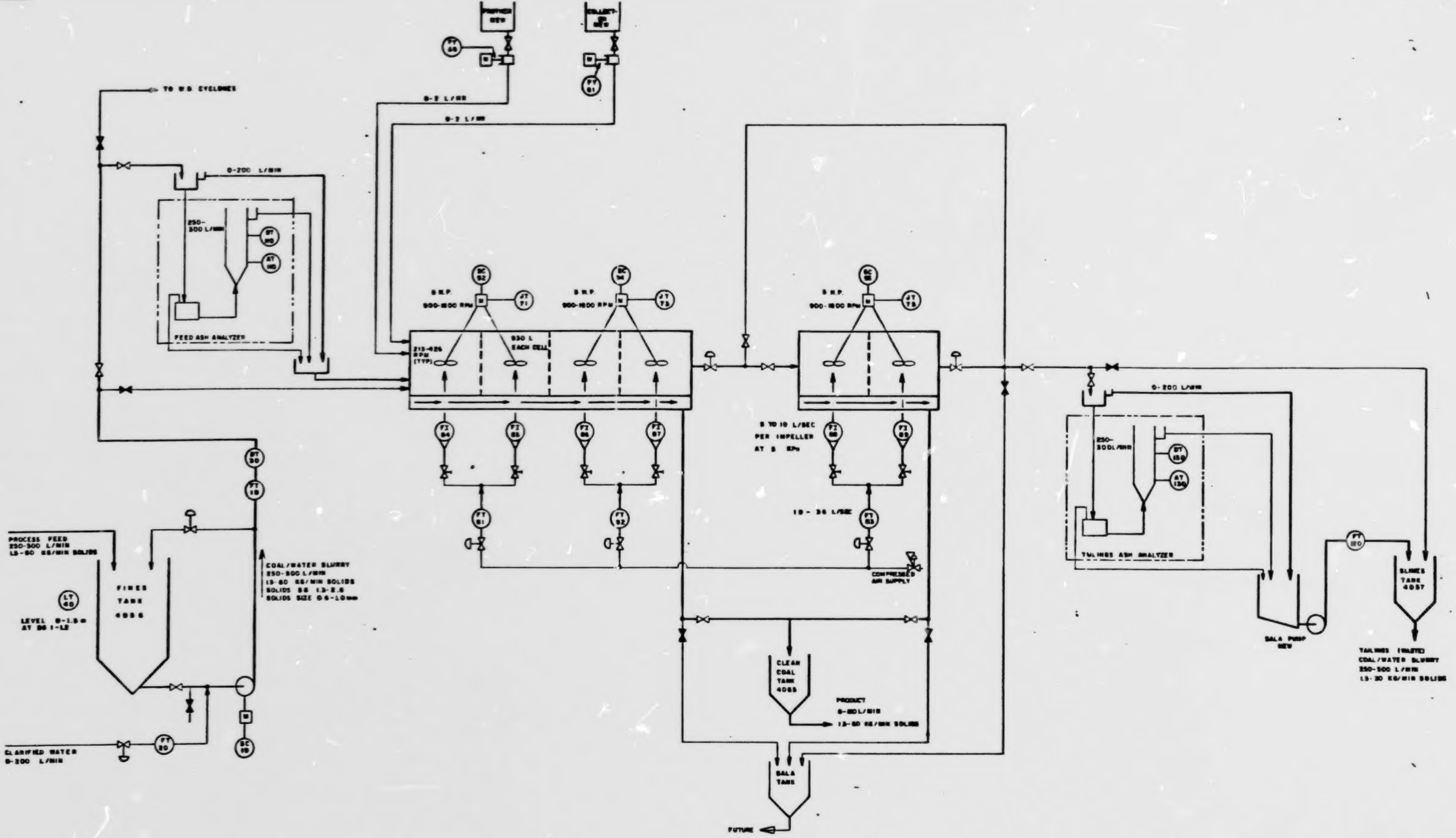
The Phase II Report was delivered in September, 1984.

1.0 INTRODUCTION

1.4 Phase III Procedure

The execution of Phase III was done in this way:

- Redraw a Process Flow Sheet and a Piping and Instrument Diagram to show the control plan in more detail.
- Obtain quotes and literature from potential suppliers of the instruments and the process control system.
- Obtain quotes and literature about the ash analyzer.
- Prepare installation (piping) drawings.
- Prepare instrument specifications - data sheets.
- Evaluate process control systems.
- Write and run computer programs to check the Process Flow Sheet Values and to simulate the calculations required of the process control system.
- Prepare electrical/instrumentation installation drawing.


TO W.S. CYCLONES
0-200 L/MIN
250-300 L/MIN
ST 110
AT 110
FEED ASH ANALYZER
FRОTHER MEW
COLLECTOR MEW
FY 66
FY 61
0-2 L/HR
0-2 L/HR
SC 52
5 H.P.
900-1800 RPM
JT 71
SC 54
5 H.P.
900-1800 RPM
JT 73
213-426 RPM (TYP)
930 L EACH CELL
FI 64
FI 65
FI 66
FI 67
FT 81
FT 82
SC 56
5 H.P.
900-1800 RPM
JT 75
5 TO 10 L/SEC PER IMPELLER AT 5 KPa
FI 68
FI 69
10 - 36 L/SEC
FT 83
COMPRESSED AIR SUPPLY
CLEAN COAL TANK 4055
PRODUCT
0-80 L/MIN
13-50 KG/MIN SOLIDS
SALA TANK
FUTURE
ST 30
FT 10
PROCESS FEED
250-300 L/MIN
15-60 KG/MIN SOLIDS
FINES TANK 4056
LT 40
LEVEL 0-1.5 m AT SG 1-1.2
COAL/WATER SLURRY
250-300 L/MIN
15-60 KG/MIN SOLIDS
SOLIDS SG 1.3-2.6
SOLIDS SIZE 0.5-1.0mm
M
SC 10
CLARIFIED WATER
0-200 L/MIN
FT 20
0-200 L/MIN
250-300L/MIN
ST 130
AT 130
TAILINGS ASH ANALYZER
SALA PUMP
NEW
FT 120
SLIMES TANK 4057
TAILINGS (WASTE)
COAL/WATER SLURRY
250-300 L/MIN
15-30 KG/MIN SOLIDS

		1	GENERAL REV'D	28-JAN-85			
DWG No	REFERENCE DRAWINGS	No	DESCRIPTION	DATE	APR VD	NAME	DATE
		REVISIONS			CLIENT AUTHORIZATION		

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER

SCALE NONE
DESIGNED
DRAWN R.A.H.
CHECKED
APPROVED
DATE

the cambrian engineering group limited

AMC Associated Mining Consultants Ltd.

Energy, Mines and Resources Canada
Canada Centre for Mineral and Energy Technology

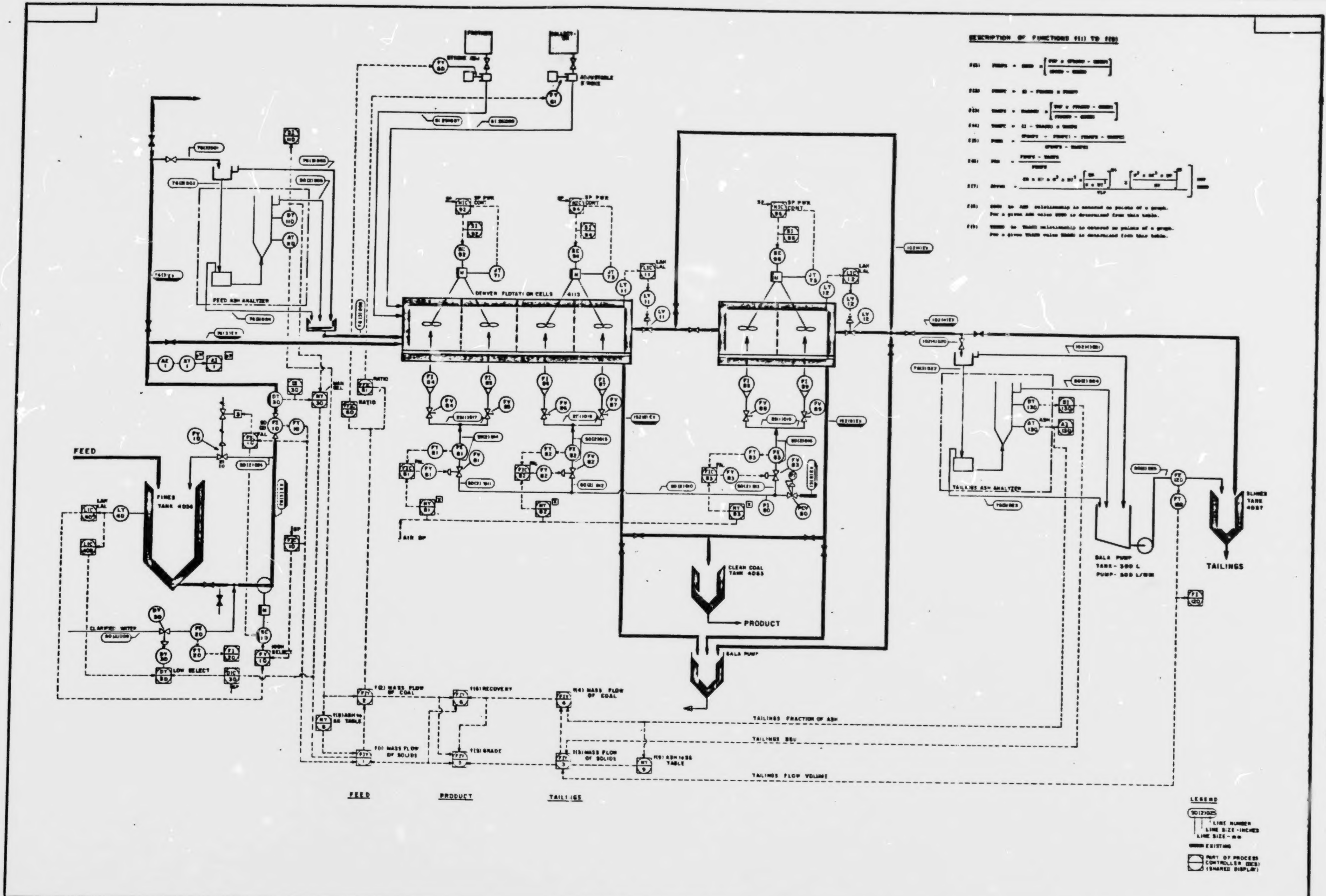
Development of a Coal Froth Flotation Control System

TITLE
PROCESS FLOW SHEET

PROJECT NUMBER
83333/PB270300

DRAWING NUMBER
01

REV
1


FEED
FINES TANK 4036
LAH LAL
LIC 40
LT 40
CLARIFIED WATER
LOW SELECT
HIGH SELECT
RATIO
FEED ASH ANALYZER
DENVER FLOTATION CELLS 4113
SP PWR CONT
AIR SP
CLEAN COAL TANK 4083
PRODUCT
SALA PUMP
TAILINGS ASH ANALYZER
SALA PUMP TANK - 300 L PUMP - 300 L/MIN
SLIMES TANK 4037
TAILINGS
f(2) MASS FLOW OF COAL
f(8) ASH to SG TABLE
f(1) MASS FLOW OF SOLIDS
f(6) RECOVERY
f(5) GRADE
f(4) MASS FLOW OF COAL
f(3) MASS FLOW OF SOLIDS
f(9) ASH to SG TABLE
TAILINGS FRACTION OF ASH
TAILINGS SGU
TAILINGS FLOW VOLUME
FEED
PRODUCT
TAILINGS
LEGEND
LINE NUMBER
LINE SIZE - INCHES
LINE SIZE - mm
EXISTING
PART OF PROCESS CONTROLLER (DCS) (SHARED DISPLAY)

DESCRIPTION OF FUNCTIONS f(1) TO f(9)

f(8) [illegible] to ASH relationship is entered as points of a graph. For a given ASH value [illegible] is determined from this table.

f(9) [illegible] to [illegible] relationship is entered as points of a graph. For a given [illegible] value [illegible] is determined from this table.

DWG No	REFERENCE DRAWINGS

No	DESCRIPTION	DATE
1	GENERAL REV'T	28-JAN-85

REVISIONS

APR VD	NAME	DATE

CLIENT AUTHORIZATION

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER
P 2861
The Cambrian Engineering Group Ltd.

SCALE	NONE	DATE
DESIGNED	RAH/ALC	DEC84
DRAWN	R A H	DEC84
CHECKED		
APPROVED		

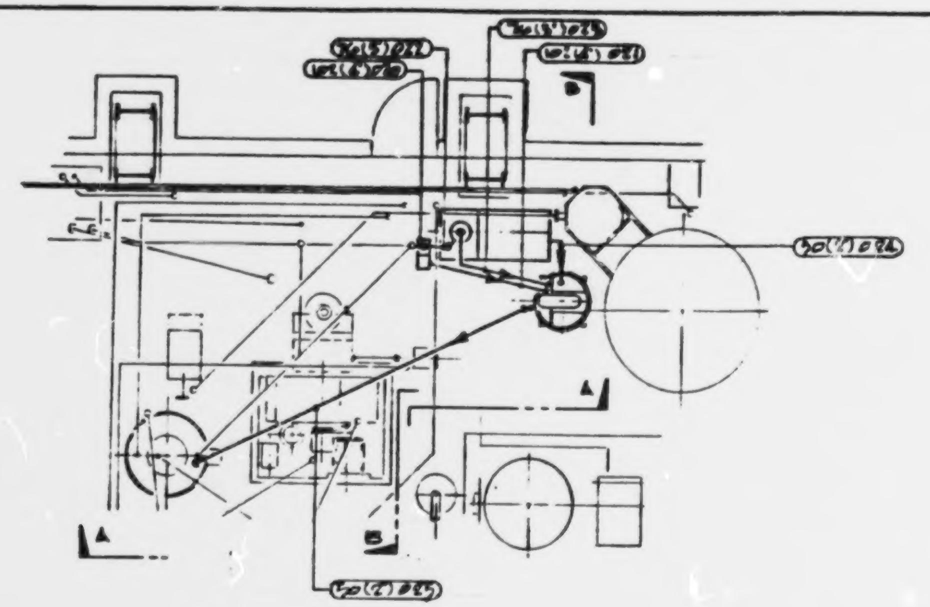
the cambrian engineering group limited

AMCL Associated Mining Consultants Ltd.

Energy, Mines and Resources Canada
Canada Centre for Mineral and Energy Technology
Development of a Coal Froth Flotation Control System

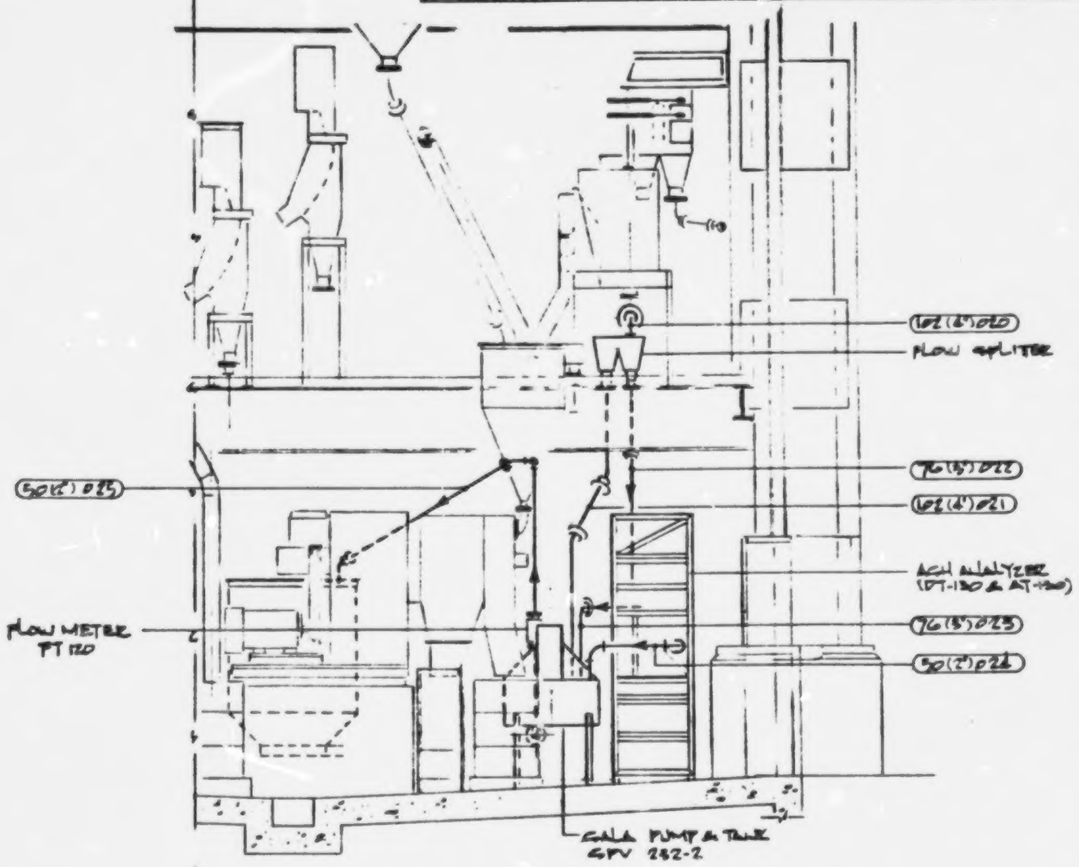
TITLE
PIPING AND INSTRUMENT DIAGRAM

PROJECT NUMBER
83333/PB270300
DRAWING NUMBER
02
REV
1

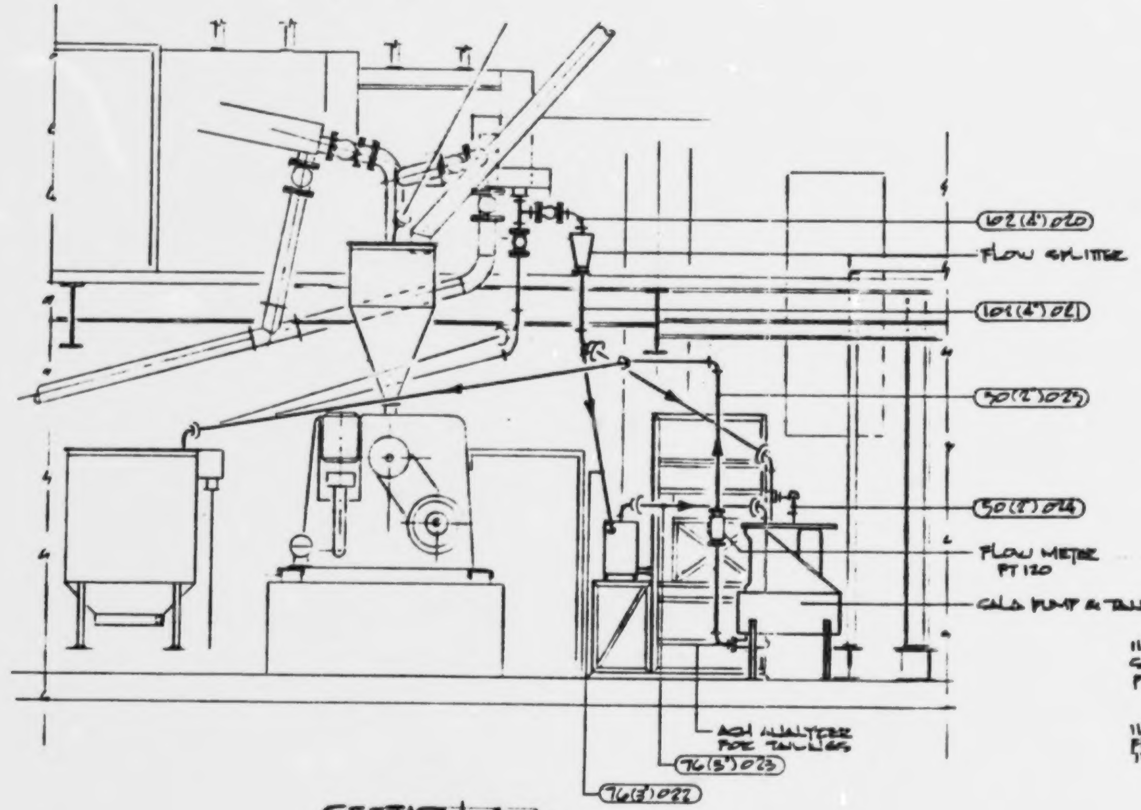

50(2")022
102(4")020
76(3")023
102(4")021
50(2")026
50(2")025

PLAN
(GROUND FLOOR)
SCALE 1:30

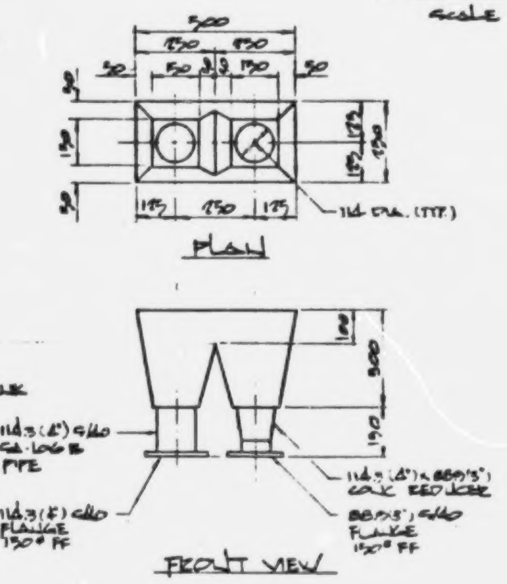
BILL OF MATERIAL


102(4")020
FLOW SPLITTER
50(2")025
76(3")022
102(4")021
ASH ANALYZER (DT-130 & AT-130)
FLOW METER FT 120
76(3")023
50(2")026
CALA PUMP & TANK GPV 282-2

SECTION B-B
SCALE 1:30


102(4")020
FLOW SPLITTER
102(4")021
50(2")023
50(2")024
FLOW METER FT 120
CALA PUMP & TANK
ASH ANALYZER FOR TAILINGS
76(3")023
76(3")022

SECTION A-A
SCALE 1:30


500
250
250
50
150
150
50
125
250
125
114 DIA. (TYP.)
100
500
190
114.3(4") SCH40 SA-106 B PIPE
114.3(4") SCH40 FLANGE 150# FF
114.3(4")x 88.9(3") CONC REDUCER
88.9(3") SCH40 FLANGE 150# FF

PLAN

FRONT VIEW

FLOW SPLITTER
SCALE 1:10

REVISIONS						REFERENCE DRAWINGS	
NO.	DESCRIPTION	BY	DATE	CHKD	APPD	DWG. NO.	DESCRIPTION
△	PT-130 & AT-130 NOTED					01	PROCESS FLOW SHEET
△						02	P & I DIAGRAM
△							
△							
△							
△							
△							

DISTRIBUTION

CLIENT APPROVAL
APPROVAL DATE

DRAWING STATUS
ISSUED
PRELIMINARY
FOR PHASE III REPORT 18-2-85
APPD. FOR CONSTRUCTION
REV. & APPD. FOR CONSTRUCTION △
NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REVISION

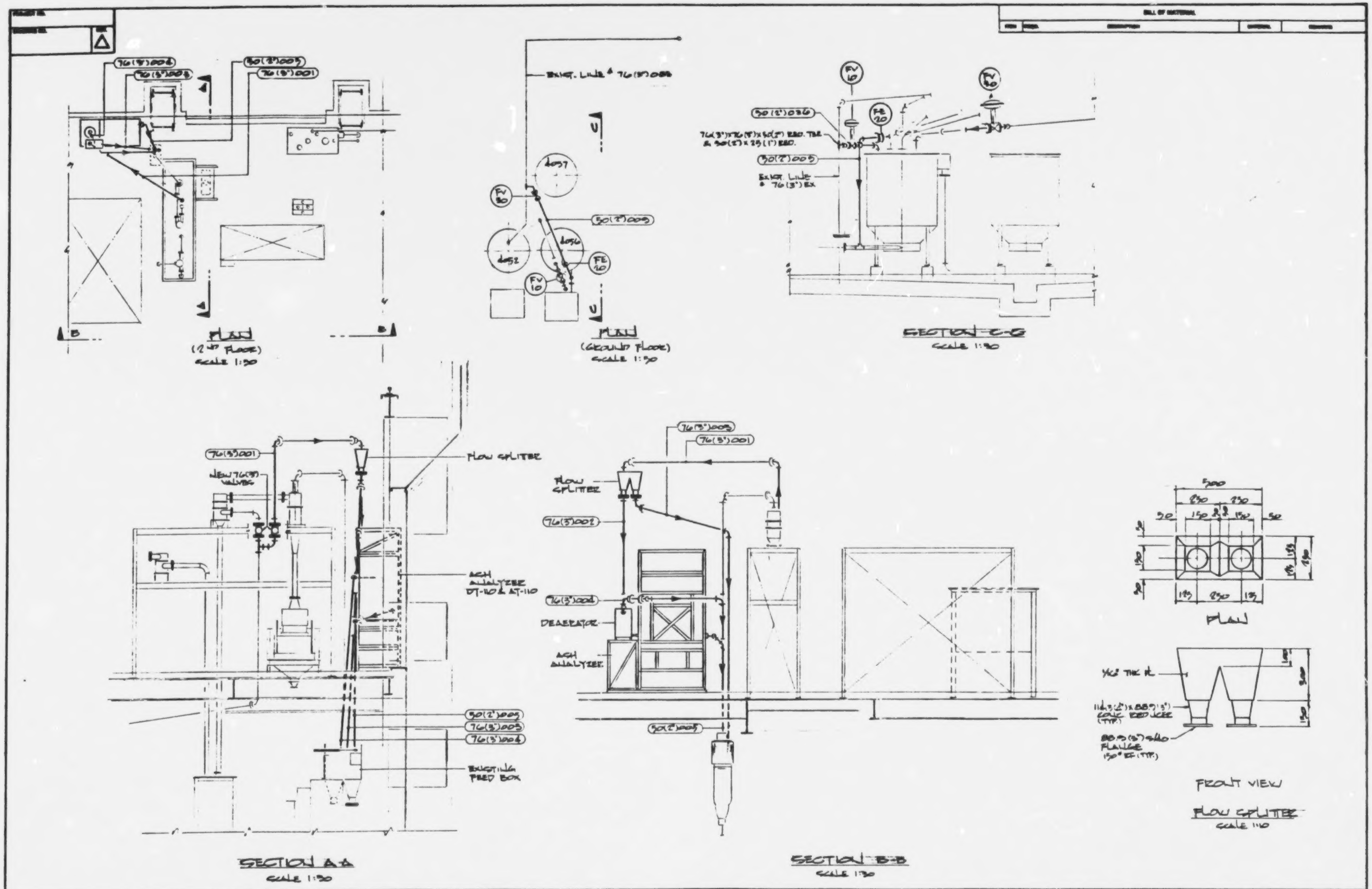
PERMIT NO.
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER
P 381
The Cambrian Engineering Group Limited

STAMP
PROFESSIONAL ENGINEER ALBERTA

the cambrian group

CLIENT ZALMET-COAL RESEARCH LAB.
FROTH FLOTATION CONTROL SYSTEM
TAILINGS ASH ANALYZER
PLAN & SECTIONS
THE CAMBRIAN ENGINEERING GROUP LIMITED

DESIGN RAH
SCALE AS SHOWN
DRAWN B. YIM
DATE JAN. 85
CHECKED
DATE
PROJECT NO. B-3335
DRAWING NO. 03
REV. △



76(3")006
76(3")003
50(2")003
76(3")001
PLAN
(2ND FLOOR)
SCALE 1:30
EXIST. LINE ⌀ 76(3")065
dc37
FV 30
50(2")005
dc36
dc32
FE 20
FV 10
PLAN
(GROUND FLOOR)
SCALE 1:30
FV 10
FV 60
FE 20
50(2")036
76(3")x76(3")x50(2") RED. TEE & 50(2")x25(1") RED.
50(2")005
EXIST. LINE ⌀ 76(3")EX
SECTION C-C
SCALE 1:30
76(3")001
NEW 76(3") VALVES
FLOW SPLITTER
ASH ANALYZER DT-110 & AT-110
50(2")005
76(3")003
76(3")004
EXISTING FEED BOX
SECTION A-A
SCALE 1:30
76(3")003
76(3")001
FLOW SPLITTER
76(3")002
76(3")004
DEAERATOR
ASH ANALYZER
50(2")005
SECTION B-B
SCALE 1:30
500
230
230
50
150
150
50
PLAN
3/16" THK PL
114.3(4")x88.9(3") CONC. REDUCER (TYP.)
88.9(3") S/O FLANGE 150# RF (TYP.)
FRONT VIEW
FLOW SPLITTER
SCALE 1:10

REVISIONS						REFERENCE DRAWINGS		DISTRIBUTION	CLIENT APPROVAL		DRAWING STATUS	
NO	DESCRIPTION	BY	DATE	CHKD	APPD	DWG NO	DESCRIPTION		APPROVAL	DATE	ISSUED	
△	DT-110 & ET-110 NOTED, MOVE FE-20					01	PROCESS FLOW SHEET		△		PRELIMINARY FOR PHASE III REPORT	8-2 85
△	& ADDED LINE 50(2")026	BY	7/85			02	P&I DIAGRAM		△		APPD. FOR CONSTRUCTION	
△								CLIENT	△		REV. & APPD. FOR CONSTRUCTION △	
△									△		NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND OR REVISION	
△								FIELD	△			
△									△			
△									△			

PERMIT NO

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER
P 381
The Cambrian Engineering Group Limited

STAMP

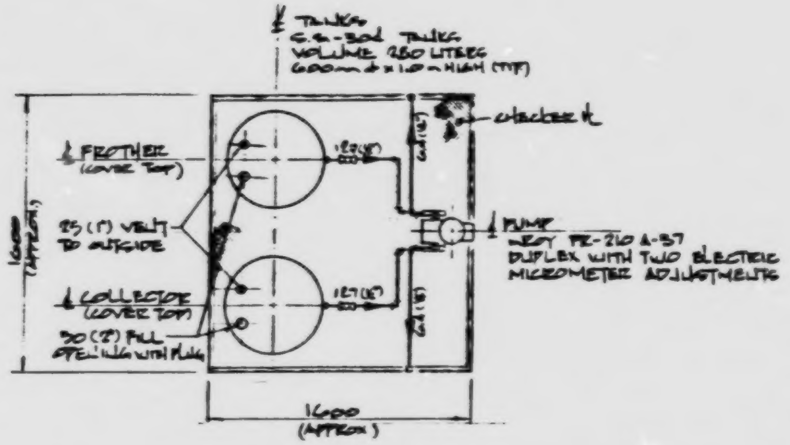
the cambrian group

CLIENT CANMET COAL RESEARCH LAB.

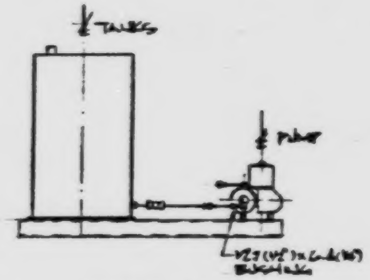
FROTH FLOTATION CONTROL SYSTEM
FEED ASH ANALYZER
PLANS & SECTIONS

THE CAMBRIAN ENGINEERING GROUP LIMITED

DESIGN E.A.H.	SCALE AS SHOWN
DRAWN B.TM	DATE JAN 85
CHECKED	DATE
PROJECT NO. B 3333	
DRAWING NO. 06	REV. △

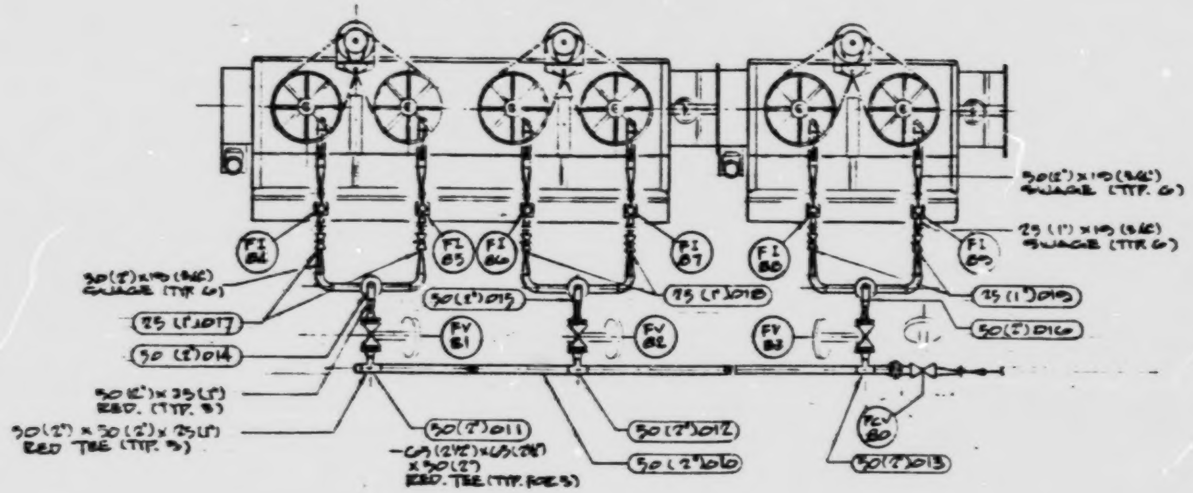

℄ TANKS
C.S.-304 TANKS
VOLUME 280 LITERS
600mm ⌀ × 1.0m HIGH (TYP)
CHECKER PL
℄ FROTHER (COVER TOP)
12.7(½")
25 (1") VENT TO OUTSIDE
℄ PUMP
WEST PR-210 A-37
DUPLEX WITH TWO ELECTRIC MICROMETER ADJUSTMENTS
℄ COLLECTOR (COVER TOP)
50 (2") FILL OPENING WITH PLUG
1600 (APPROX)
1600 (APPROX)

PLAN

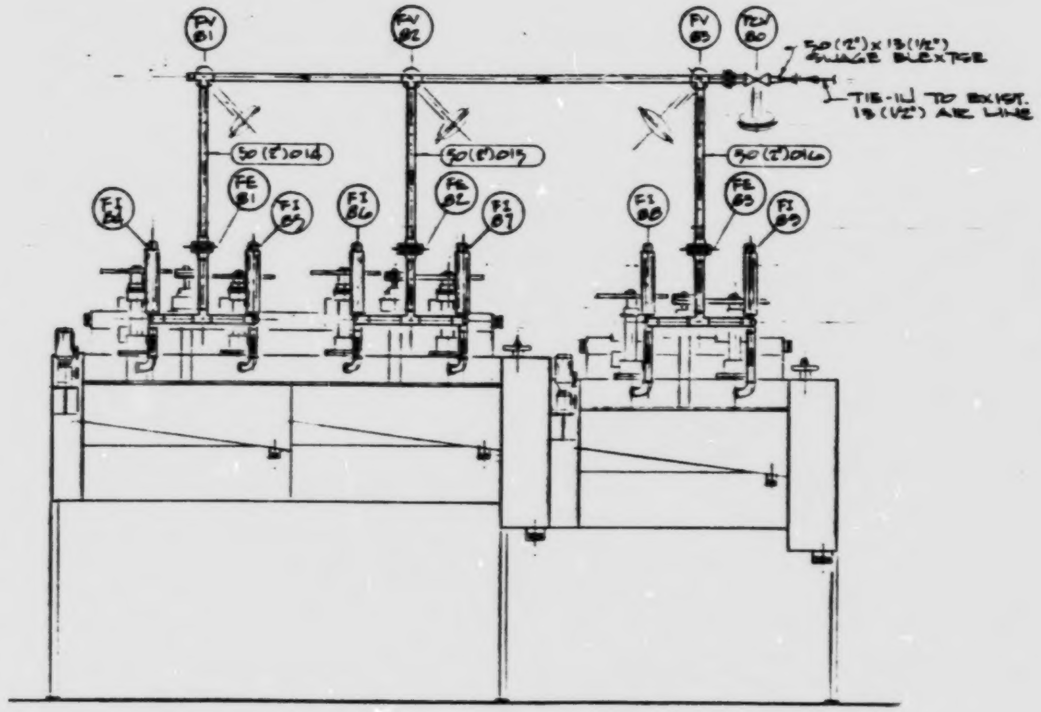

℄ TANKS
℄ PUMP
12.7(½") × 6.4(¼") BUSHING

FRONT VIEW

REAGENT PUMP & TANKS
SCALE 1:20


50(2")×19(3/4") SWAGE (TYP. 6)
25 (1")×19 (3/4") SWAGE (TYP. 6)
FI 84
FI 85
FI 86
FI 87
FI 88
FI 89
50(2")×19(3/4") SWAGE (TYP 6)
25 (1")017
50(2")015
25 (1")018
25 (1")019
50(2")016
50 (2")014
FV 81
FV 82
FV 83
50(2")×25(1") RED. (TYP. 3)
50(2")×50(2")×25(1") RED TEE (TYP. 3)
50(2")011
63(2½")×63(2½")×50(2") RED. TEE (TYP. FOR 3)
50(2")012
50(2")010
PCV 80
50(2")013

PLAN


FV 81
FV 82
FV 83
PCV 80
50(2")×13(½") SWAGE BLEXTGE
TIE-IN TO EXIST. 13(½") AIR LINE
50(2")014
50(2")015
50(2")016
FI 84
FE 81
FI 85
FI 86
FE 82
FI 87
FI 88
FE 83
FI 89

FRONT VIEW

FLOTATION CELLS AIR
SCALE 1:20

REVISIONS						REFERENCE DRAWINGS	
NO.	DESCRIPTION	BY	DATE	CHK	APPD	DWG. NO.	DESCRIPTION
△	AIR LINE SIZES REV'D	BY	FEB			01	PROCESS FLOW SHEET
△						02	P&I DIAGRAM
△							
△							
△							
△							
△							

DRAWING STATUS
PRELIMINARY: FOR PHASE III REPORT 18 7 85
APPD. FOR CONSTRUCTION
REV. & APPD. FOR CONSTRUCTION △
NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REVISION

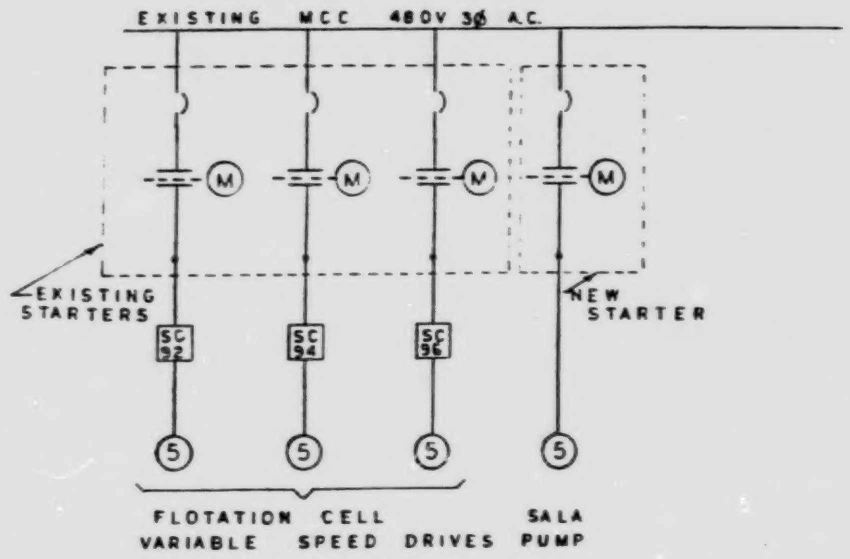
PERMIT NO.
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER
The Cambrian Engineering Group Limited

the cambrian group

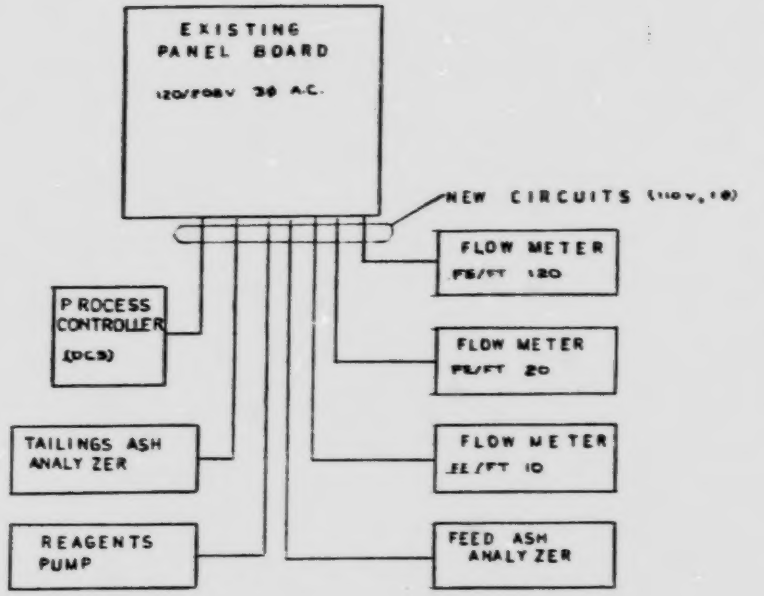
CLIENT: CANMET COAL RESEARCH LAB.
FROTH FLOTATION CONTROL SYSTEM
PIPING AIR CONTROL
PLUS
REAGENT TANKS & PUMP
THE CAMBRIAN ENGINEERING GROUP LIMITED

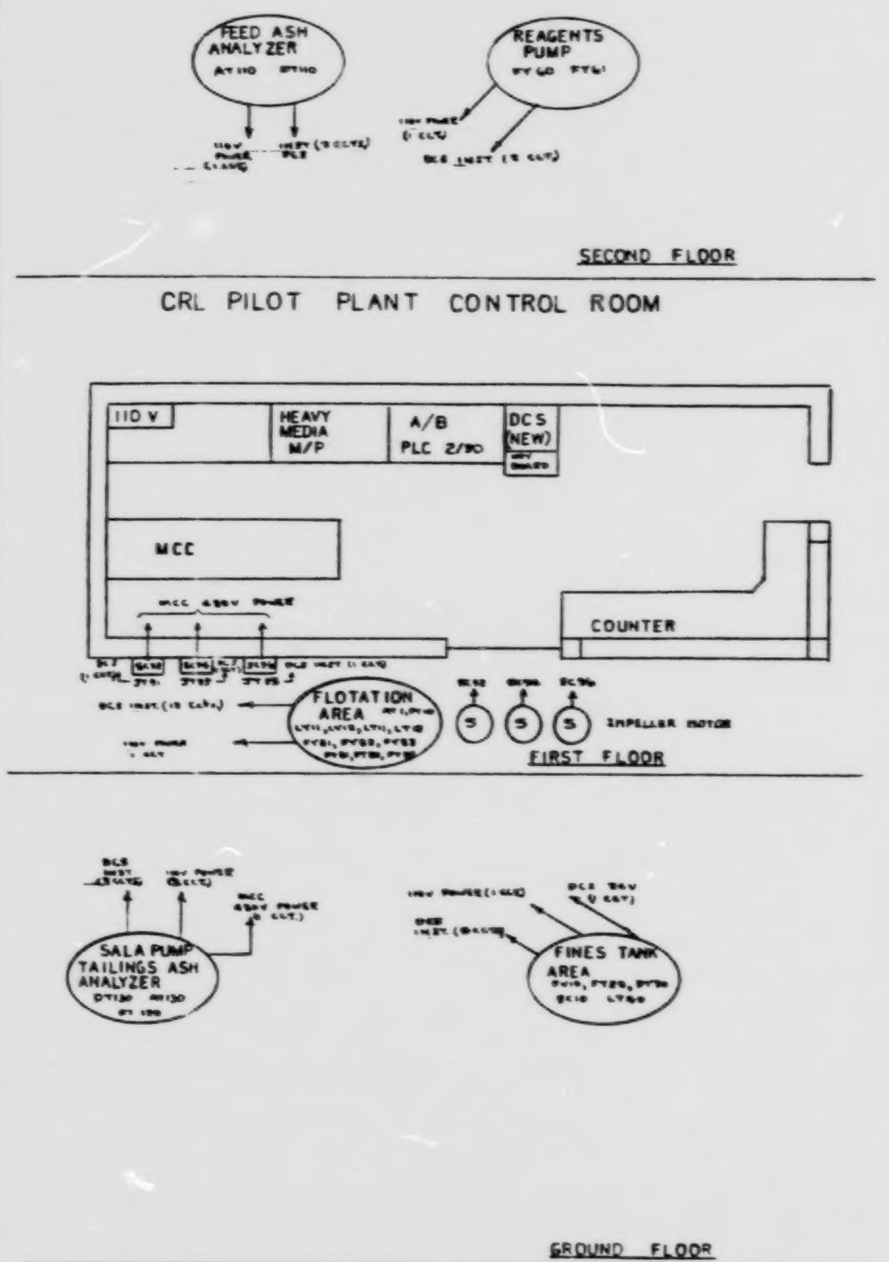
DESIGN: RAH
SCALE: 1:20
DRAWN: B. YM
DATE: JUL 85
CHECKED:
PROJECT NO. B-3333
DRAWING NO. 05
REV. △

480 V
SINGLE LINE DIAGRAM


EXISTING MCC 480V 3Ø A.C.
M
EXISTING STARTERS
NEW STARTER
SC 92
SC 94
SC 96
5
FLOTATION CELL VARIABLE SPEED DRIVES
SALA PUMP

110 V DISTIBRUTION


EXISTING PANEL BOARD 120/208V 3Ø A.C.
NEW CIRCUITS (110V, 1Ø)
FLOW METER FE/FT 120
FLOW METER FE/FT 20
FLOW METER FE/FT 10
FEED ASH ANALYZER
PROCESS CONTROLLER (DCS)
TAILINGS ASH ANALYZER
REAGENTS PUMP


FEED ASH ANALYZER
AT110 DT110
110V POWER
INST (2 CCTS) DCS
REAGENTS PUMP
FY60 FY61
110V POWER (1 CCT)
DCS INST (2 CCT)
SECOND FLOOR
CRL PILOT PLANT CONTROL ROOM
110 V
HEAVY MEDIA M/P
A/B PLC 2/30
DCS (NEW)
MCC
MCC 480V POWER
COUNTER
FLOTATION AREA
LT11, LY13, LT11, LT13
FY51, FY53, FY55
5
IMPELLER MOTOR
FIRST FLOOR
SALA PUMP TAILINGS ASH ANALYZER
DT130 AT130
FT 120
DCS INST
110V POWER
MCC 480V POWER
FINES TANK AREA
FT20, DT20
SC10 LT40
DCS 24V
GROUND FLOOR

BILL OF MATERIAL

ITEM	REQD.	DESCRIPTION	MATERIAL	REMARKS

CIRCUIT SCHEDULE

INST./FIELD LOCATION	INST. I.D.	120V POWER REQUIRED YES NO	SIGNAL CIRCUIT VOLTAGE/ CURRENT LEVEL	APPROX. CIRCUIT LENGTH	REMARKS
Float Tank Ground Floor	FT 10	X	4-20 ma DC	13 m	Turbine Flow Meter Signal wiring from FE 10 to FT 10 also req'd (wire by Mfg.)
"	DT 20	X	"	13 m	DT 20 mounted on existing valve.
"	SC 10	X	"	13 m	SC 10 mounted on existing drive.
"	LT 40	X	"	13 m	D/P cell
"	FV 10	X	24V DC	13 m	Signal to solenoid valve integral with FV 10.
New Sala Pump Ground Floor	FT120	X	4-20 ma DC	15 m	Magnetic flow meter. 480V req'd for Sala Pump.
Froth Flotation 1st Floor	FT 50	X	4-20 ma DC	14 m	Magnetic flowmeter.
"	FT 51	X	"	12 m	DP cell.
"	FT 53	X	"	12 m	"
"	FT 55	X	"	12 m	"
"	FY 51	X	"	13 m	Valve mounted I/P transducer.
"	FY 53	X	"	13 m	"
"	FY 55	X	"	13 m	"
"	AT 1	X	"	14 m	Mounted on pH cell.
"	LY 11	X	"	14 m	Mount at existing valve.
"	LY 13	X	"	14 m	"
"	LT 11	X	"	14 m	D/P cell.
"	LT 13	X	"	14 m	"
Feed Ash Analyzer 2nd Floor	DT110	X	4-20 ma DC	20 m	Common 110V AC Power Supply
	AT110	X	"	20 m	
Tailings Ash Analyzer Ground Floor	DT130	X	4-20 ma DC	26 m	Common 110V AC Power Supply
	AT130	X	"	26 m	
Control Room 1st Floor	DT 20	X	4-20 ma DC	8 m	Existing
"	SC 92	see remarks	"	4 m on @ 480 V plus	480 V A.C Power Required
"	SC 94	see remarks	"	9 m on @	"
"	SC 96	see remarks	"	4-20 ma	"
"	JT 71	X	"	9 m	Integral with SC 92
"	JT 73	X	"	9 m	Integral with SC 94
"	JT 75	X	"	9 m	Integral with SC 96
Reagents Skid	FY 60	X X	"	14 m	Both mounted on on duplex pump. Need
	FY 61	X	"	14 m plus 25 m @ 110 V	110V for pump motor.

INSTALLATION SPECIFICATION

1. All wiring shall be installed in conduit, which shall be rigid threaded galvanized steel, 3/4" minimum. All junction boxes and fittings shall be cast, corrosion resistant type condulets.
2. Connections to equipment and instruments shall be made with "Sealtite", PVC jacketed, waterproof, flexible conduit.
3. Instrument signal wiring shall be Belden No. 8760, 18 gauge, 16 x 30 stranded, foil shield, with drain wire, polyethylene jacket.
4. Power wiring at 600V A.C., 120V A.C. and 24V D.C. shall be stranded copper, RW90, X-link insulation type, rated at 600V.
5. Motor starter for Sala pump shall match existing equipment.
6. The complete installation shall meet the requirements of the Canadian Electrical Code, CSA, and Alberta standards.

REVISIONS						REFERENCE DRAWINGS		DISTRIBUTION	CLIENT APPROVAL		DRAWING STATUS	
NO.	DESCRIPTION	BY	DATE	CHKD.	APPD.	DWG. NO.	DESCRIPTION		APPROVAL	DATE	ISSUED	
△						02	P+I DIAGRAM		△		PRELIMINARY FOR PHASE II REPORT	15-2-85
△									△		APPD. FOR CONSTRUCTION	
△									△		REV. & APPD. FOR CONSTRUCTION △	
△									△		NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED AND DATED. DESTROY ALL PRINTS BEARING EARLIER DATE AND/OR REVISION	

PERMIT NO.
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER P 331
The Cambrian Engineering Group Limited

STAMP
Feb 15 /85

the cambrian group

CLIENT: CANMET COAL RESEARCH LAB

FROTH FLOTATION CONTROL SYSTEM
ELECTRICAL
POWER AND INSTRUMENTATION
CIRCUITS

THE CAMBRIAN ENGINEERING GROUP LIMITED

DESIGN: BP
SCALE: NTS
DRAWN: BP
DATE: FEB 7, 1985
CHECKED: [illegible]
DATE: FEB 85
PROJECT NO. B3333
DRAWING NO. 06
REV. △

2.0 DETAILED DESIGN DRAWINGS

2.1 Process Flow Sheet and Discussion

2.1.1 General

Drawing 01 is the Process Flow Sheet. This drawing shows quantities of flows expected and characteristics of those flows. Pipe sizes and instrument and control valve selections are based on these flows and any inaccuracies may result in instruments or control valves which do not function as well as they should.

2.1.2 Source of Data for Flows

The flows are taken from the Phase II drawings which were reviewed and approved by the Coal Research Lab. It is strongly suggested that Coal Research Lab personnel review these flows again. If ranges can be tightened up, a better instrument selection may be possible. Both the low and the high number for each flow should be checked before purchases are made.

2.1.3 Air Flows

(a) Original Calculation

The air flow volumes were first calculated this way:
Data from Dr. Zaragosa at the University of Utah:

- A one cubic foot laboratory cell takes 35-40 cu ft/min.
- Commercial cells of 100 cubic foot volume take 15-25 cu ft/min per cubic foot of cell volume.

The Canmet Coal Research Lab cells are 10 cubic feet each.

The mid points of the above values are approximately 20 cfm/ft^3 for 100 ft^3 size cell and 37½ cfm/ft^3 for 1 ft^3 size cells. Using a straight line graph between these two points gives 36 cfm/ft3 for a 10 ft3 size cell. The range expected is ±6 cfm by comparison to data from above. Thus the expected usage is 30 to 42 cfm/ft3 of cell volume.

For a 10 cubic foot sized cell the expected air use is therefore 300 to 420 cfm. Converting to metric this is 141 to 198 liters/second.

(b) Subsequent Calculation

The air flows calculated above are quite large, actually exceeding the stated capacity of the Coal Research Lab air compressors (two units rated 38 cfm at 150 psi each). This finding led to a re-evaluation of the quantity of air required. The final numbers which are shown on Drawing 01 Rev 1 (or later) are based on advice from Mr. Jim Edward of Joy Manufacturing, Denver Division, Kitchener, Ontario. He stated that the air requirement of these 10 cubic foot cells in coal service is 20 cfm/cell at 12 ounces per square inch pressure. This converts to 9.44 liters/second at 5 kPa. The range was arbitrarily selected at 5 to 18 liters/second per cell at 5 kPa.

Thus the air volume required at 5 kPa is 10 to 36 liters/second for 2 cells and 30 to 108 liters/second for 6 cells. Volumes at higher pressures are of course correspondingly lower. Pressure after the PCV80 but before the control valaves FV 81, FV 82, FV 83, is to be 420 kPa (30 psi). This allows for sufficient drop across the control valves, the orifices (FE 81, FE 82, FE 83) and the flow indicators (rotameters) FI 84 thru FI 89.

The reason for the discrepancy between the calculated air flows 5 to 18 liters/second per cell vs. 141 to 198 liters/second per cell has not been determined. It would be prudent to attempt measurements of air flow while the cells are in use before committing to piping, valves, orifice plates, and rotameters of the specified size.

2.1.4 Dilution by Clairifed Water

Dilution of the feed, to maintain a constant percent solids and therefore a constant mass flow rate to the flotation cells, has been relocated to the Fines Tank Pump suction. This location is best because

1) the velocity through the existing line leading from this pump up to the cyclones is not reduced while dilution is occurring. The velocity is minimal to keep solids suspended if flow rate is toward the low end (250 l/min) of the range. Adding dilution water at the flotation cell, and holding the total flow to 250 l/min would mean less than 250 l/min through this line. Velocity would drop and solids might settle out.

2) fines tank volume is not used up for dilution. Fines tank volume is going to impose a limit on how constant the volume flowrate to the cells can be maintained. Adding dilution water to the fines tank would use up some of this volume, therefore leaving less volume to absorb fluctuations in the feed to the fines tank from the rest of the pilot plant.

2.0 DETAILED DESIGN DRAWINGS

2.2 Piping and Instrument Diagram and Discussion

2.2.1 General

Drawing 02 shows all measuring instruments and final control devices required for the most complex control strategy outlined in our Phase II report. The controllers and indicators shown are the maximum that should be implemented for automatic control schemes of the Setpoint to Process Variable type.

Any additional control inputs to the system would have to be based on results predicted by a mathematical system model. Such a model would best be implemented on the HP 1000 computer. See Section 5 for further discussion of this point.

The process variable measuring devices and the process variable manipulation devices shown include all measurements and manipulations requested by the Coal Research Lab in the October 19th 1984 letter and in the October 28, 1984 meeting which briefly outlined the basis on which Phase III of the work was to proceed.

The early revisions of Drawing 02 showed a calculation of specific power. Further review of this with Dr. Herbst of the University of Utah revealed that this calculation cannot be used in place of a measurement of power because some of the constants are not known. See Section 4 of this report for more discussion of Specific Power and Impeller Speed Control.

The P & ID (Drawing 02) shows new instruments associated with flotation cell level control. The existing bubbler can be used, but new transmitters LT 11 and LT 12 are required to provide electrical analog input to the controller. Also the existing air operated control valve can be used but new I/P transducers LY 11 and LY 12 are required. This new arrangement is required to bring cell level control into the same system as all the other parts of the flotation process.

2.2.2 Fines Tank Level Control, Density Control, Feed Flow Control

The instruments shown control the density of the feed and the flow of the feed within the limits of the capacity of the fines tank to absorb fluctuations.

Some examples will help to explain this.

Example One - Tank Becomes Too Full

LIC 40B output becomes lower than DIC 30 output. DY 30 selects the lower value and DV 30 closes. Less dilution water combined with constant pump speed (constant flow at FE 10) means the tank level reduces. As soon as the tank level is low enough, control of dilution changes back to DIC 30.

Example Two - Tank Becomes More Full Than Example One

DV 30 is closed completely by the control described in Example One. Tank continues to fill. LIC 40A output becomes higher than FIC 10 output. FY 10 selects the higher value and increases the flow via SC 10. As soon as tank level reduces to a safe level, control of the flow volume rate reverts to FIC 10.

Example Three - Normal Running

DIC 30 setpoint and FIC 10 setpoint are such that fines tank level stays in the middle area. Control of flow is by FIC 10; control of density is by DIC 30. Note that manual select NY 30 allows the density measurement to come from the existing K RAY, DT 30, or from the new ash analyzer density section, DT 110.

Example Four - Tank Too Low

Alarm raised by LIC 40A. Operator may decide to reduce setpoint to FIC 10. To prevent a flow so low that solids will settle out, FSL 10 reacts to too low a flow by shutting off the pump (SC 10 to 0 speed). At the same time FV 10 opens to allow the line to drain back to the fines tank.

2.0 DETAILED DESIGN DRAWINGS

2.3 Piping Drawings

2.3.1 Drawing for Tailings Ash Analyzer

Drawing No. 03 shows the new piping required to install the ash analyzer for tailings. An outline of the analyzer, with deaerator, and an outline of the Sala tank and pump is also shown.

In the existing system, tailings flow from the last flotation cell to the slimes tank via a 102 mm (4") line. A valve and tee are added to this line so that the flow can be diverted to a box. From this box, if the analyzer is not in use, the entire flow can go through line 102(4")021 to the new Sala pump. This pump moves the tailings through line 50(2")025 to its original destination, the slimes tank. If desired, the new valve in the existing 102 mm line can be left open and tailings will flow directly to the slimes tank via the old route.

If the analyzer is in use, a portion of the flow goes by line 76(3")022 to the deaerator. Frothy overflow from the deaerator goes via line 76(3")023 to the new Sala tank. Deaerated tailings go from the deaerator into the analyzer chamber. Flow is up through the analyzer and the analyzer chamber overflows to line 50(2")024 leading to the new Sala tank. Note that the overflow from the ash analyzer must be higher than that shown on the ash analyzer drawings we have. This is simply a change of piping in the ash analyzer. All flows are eventually returned to the slimes tank by the new Sala tank and pump.

The ash analyzer also requires a small line supplying water (for calibration) and a drain for this water. Drain would be onto the floor; supply would be from a convenient source. Ideally the calibration water should be similar to water used for flotation slurry.

The total volumetric flow of tailings is measured by FT 120 which is located in the only full line available, the discharge from the new Sala pump. This flowmeter is positioned in the rising portion of the line and should be 2/3 from the bottom and 1/3 from the top of this rising portion in order to optimize length of straight pipe upstream and downstream from the flowmeter.

2.3.2 Drawing For Feed Ash Analyzer

Drawing No. 04 shows the installation location and new piping for the ash analyzer for feed. Feed to the flotation cells is taken from the existing line to the primary water only cyclone, line number 76(3")001 to a flow splitter box above the ash analyzer. If the analyzer is not in use all the flow goes via line 76(3")003 to the flotation cells. If the ash analyzer is in use a portion of the flow goes via line 76(3")002 to the deaerator. Any air or froth goes via line 76(3")004 from the top of the deaerator to flotation cells.

From the bottom of the deaerator the feed slurry flows up through the analyzer and overflows via line 50(2")005 to the flotation cells.

Drawing 04 also shows new line number 50(2")009 which provides a controlled and measured flow of clarified water to the suction of the fine coal tank pump. This water is used to dilute the feed stream to the flotation cells if it becomes too dense (too much solids). See the discussions about the Piping and Instrument Diagram and the Process Flow Sheet for more detail. The new line 50(2")009 is taken from existing line number 083, and upstream of the level control valve. Line 083 runs from the clarified water tank to the Raw Coal Tank number 4052.

FT 20 is located in new line 009 in a location which will optimize the length of straight pipe upstream and downstream.

2.0 DETAILED DESIGN DRAWINGS

2.3.3 Drawing For Air Piping And Reagent Tanks/Pump

Drawing 05 shows the piping required for control of air to the flotaiton cells, and Drawing 05 also shows reagent tanks and metering pumps.

(a) Air Piping

In order to provide a measured and controlled supply of air to the flotation cells it is necessary to abandon the existing air delivery system, and construct a completely new air delivery system.

Air supply is via a 1/2" line at 150 psi from the Coal Research Centre air compressors. Pressure is reduced to a controlled level by PCV 80. The increased volume of lower pressure air goes into a 50 mm line numbered 50(2")010. This line is located as high as possible, to be out of the way, and to allow the maximum straight length of pipe for FT 81, FT 82 and FT 83. Control valves FV 81, FV 82 and FV 83 control the flow of air to each pair of cells. The cells are treated as pairs because the impellers are motor driven as pairs. Impeller speed control can only be exercised on a pair of impellers so to match this fact, air control is exercised on a pair of cells.

After each flow element, FE 81, FE 82 and FE 83, the flow divides and is delivered to each cell.

Flow indicators (rotameters) and hand valves are provided so that the flow can be balanced between the two cells of each pair.

2.0 DETAILED DESIGN DRAWINGS

Final connection to existing air piping is in the vertical pipe located below each existing hand valve.

The final 50 mm of 50 mm (2") pipe at each cell should be flexible. Pressure at this point is low, about 1 psi above atmospheric, so hose and hose clamps would be satisfactory and simple for this connection.

All the air piping shown requires adequate support. Line 50(2")010 would certainly be supported from the ceiling and the other lines should be supported from the ceiling also. Support from the flotation cells frame is not advised because of the vibration which would be passed to the pipes.

FE 81, FE 82 and FE 83 are orifice plates. A standard 3 valve manifold is required to connect from the flange taps to the differential pressure transmitters FT 81, FT 82 and FT 83.

(b) Reagent Tanks and Pump

The reagent tanks and pump can be conveniently purchased as a small skid about 1.6 m x 1.6 m. A suggested layout is shown; however, the supplier should be given leeway to arrange the skid differently if savings would result.

(i) Pump

The pump is a duplex unit. One motor and gear system operates two independent diaphragm pumps. The stroke and therefore the delivery of each diaphragm pump is individually adjusted by an electrical capacity adjustment in response to signals from the control system. A duplex unit such as has been selected offers less cost and simpler installation than 2 pumps. Only one electrical power supply to the pump is required.

The exact model selected is a Milton Roy m Roy FR-210 A-37 with two electric capacity adjusters. Diaphragm materials to be selected by pump supplier to suit the liquids being pumped. Each side of this pump can deliver a maximum of 0.8 USGPH which converts to 3.0 liters per hour. Our requirement is 2 liters per hour.

Piping from pump outlet to be 1/4" steel flexible.

(ii) Tanks

Each tank is shown as 600 mm diameter x 1000 mm high. This gives a capacity of 282 liters which is about 62 imperial gallons. The eventual supplier should be allowed to use tanks of different dimensions if cost savings will result. Capacity should remain approximately the same.

The collector tank is shown covered and vented outside because of its flammable contents - kerosene. This tank would be filled from a drum of kerosene using a transfer pump mounted on the drum.

The frother tank will contain MIBC, methyl isobutyl carbinol. The material is rated the same flammability as kerosene, but also is rated as hazardous to health. (Rating in NFPA 325M is 2 for health and 2 for flammability). This tank is also covered and vented to outside. It would be filled from a drum with a transfer pump.

Both tanks are to be constructed from stainless steel.

Tank outlets are 1/2" threaded. Piping to pumps is to be Schedule 80 carbon steel. Valves to be steel ball valves. Pump inlet is 1/4 - 18 threaded inlet so a reduction is required just before the pump inlet.

2.0 DETAILED DESIGN DRAWINGS

2.4 Electrical Drawings

There is one electrical drawing included as part of this Phase III report. Drawing 06 - Electrical Power and Instrumentation Circuits.

This drawing shows all the power and instrument field wiring which will be required to implement the control system. There are 3 types of new wiring required.

2.4.1 480 V 3 Phase

- Circuits from the MCC to the 3 impeller drive motors are revised in order to insert the three speed controllers, SC92, SC94, SC96.
- A new 480 V 3 phase circuit is required to the new Sala pump.

2.4.2 110 V 1 Phase

Several instruments require 110 V power. The drawing shows in schematic and tabular form which instruments need 110 V power, and where they are located.

2.4.3 Instrument Wiring

The drawing shows where instrument wiring is required. Most devices require 2 wire shielded cable back to the process control system cabinet.

2.4.4 Termination Drawings

Electrical drawings showing wire numbers and terminal numbers will be required. These cannot be prepared until equipment is ordered.

CIRCUIT SCHEDULE

INST.FIELD LOCATION	INST. I.D.	110V POWER REQUIRED		SIGNAL CIRCUIT VOLTAGE/ CURRENT LEVEL	APPROX. CIRCUIT LENGTH	REMARKS
		YES	NO			
Fines Tank Ground Floor	FT 20	X		4-20 ma DC	13 m	Turbine Flow Meter Signal wiring from FE 20 to FT 20 also req'd (wire by Mfg.)
" "	DY 30		X	" "	13 m	DY 30 mounted on existing valve.
" "	SC 10		X	" "	13 m	SC 10 mounted on existing drive.
" "	LT 40		X	" "	13 m	D/P cell
" "	FV 10		X	24V DC	13 m	Signal to solenoid valve integral with FV 10.
New Sala Pump Ground Floor	FT120	X		4-20 ma DC	15 m	Magnetic flow meter. 480V req'd for Sala Pump.
Froth Flotation 1st Floor	FT 10	X		4-20 ma DC	14 m	Magnetic flowmeter.
" "	FT 81		X	" "	12 m	DP cell.
" "	FT 82		X	" "	12 m	" "
" "	FT 83		X	" "	12 m	" "
" "	FT 81		X	" "	12 m	Valve mounted I/P transducer.
" "	FT 82		X	" "	12 m	" "
" "	FT 83		X	" "	12 m	" "
" "	AT 1		X	" "	14 m	Mounted on pH cell.
" "	LY 11		X	" "	14 m	Mount at existing valve.
" "	LY 12		X	" "	14 m	" "
" "	LT 11		X	" "	14 m	D/P cell.
" "	LT 12		X	" "	14 m	" "
Feed Ash Analyzer 2nd Floor	DT110	X		4-20 ma DC	20 m	Common 110V AC Power Supply
	AT110	X		" "	20 m	

Tailings Ash Analyzer Ground Floor	DT130	X		4-20 ma DC	16 m	Common 110V AC Power Supply
	AT130	X		" "	16 m	
Control Room 1st Floor	DT 30		X	4-20 ma DC	8 m	Existing
" "	SC 92	see remarks		" "	4 m ea @ 480 V	480 V A.C Power Required
" "	SC 94	see remarks		" "	plus 9 m ea @	" " " "
" "	SC 96	see remarks		" "	4-20 ma	" "
" "	JT 71		X	" "	9 m	Integral with SC 92
" "	JT 73		X	" "	9 m	Integral with SC 94
" "	JT 75		X	" "	9 m	Integral with SC 96
Reagents	FY 60	X	X	" "	14 m	Both mounted on
Skid	FY 61		X	" "	14 m	on duplex pump. Need
					plus	110V for pump motor.
					16 m @ 110 V	

INSTALLATION SPECIFICATION

1. All wiring shall be installed in conduit, which shall be rigid threaded galvanized steel, 3/4" minimum. All junction boxes and fittings shall be cast, corrosion resistant type condulets.

2. Connections to equipment and instruments shall be made with "Sealtite", PVC jacketted, waterproof, flexible conduit.

3. Instrument signal wiring shall be Belden No. 8760, 18 gauge, 16 x 30 stranded, foil shield, with drain wire, polyethylene jacket.

4. Power wiring at 480V A.C., 110V A.C. and 24V D.C. shall be stranded copper, RW90, X-link insulation type, rated at 600V.

5. Motor starter for Sala pump shall match existing equipment.

6. The complete installation shall meet the requirements of the Canadian Electrical Code, CSA, and Alberta standards.

3.0 INSTRUMENT SPECIFICATIONS

Following is an instrument index of 10 pages and ISA instrument data sheets, 16 pages.

Also included are orifice calculations for the air flow measurement of orifice plates.

These pages are the instrument specifications.

For specifications of the Process Control System see Section 5.0 and the Appendix.

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	FE-10	WATER / COAL SLURRY	76(3)EX	02	FOXBORO	2902-SABA-ISA G			MAG [illegible]	
	FT-10			02	FOXBORO	E96T-IA				
	FIC-10			02					[illegible]	
	FY-10			02					DCS HIGH [illegible]	
	FSL-10			02					[illegible]	
	FV-10		76(2)EX	02	FISHER	1" 1051 V100			% 822053 [illegible]	
	FE-20	CLARIFIED WATER TO SLURRY	50(2)009	02	FTI	FT16CA626BS			TURBINE METER	
	FT-20			02	[illegible]	SR-1AA2BM				
	FI-20			02					DCS	
	FE-81	AIR TO FLOATATION CELL	50(2)014	02	BARBER	2"-520			BORE .875" [illegible]	
	FT-81			02	ROSEMOUNT	1151DPS			[illegible]	
	FIC-81			02					DCS	
	FY-81			02	FISHER	546			[illegible]	
	FV-81			02	FISHER	2" 667D				
	NY-81			02					DCS MULTIPLIER	
	FE-82	AIR TO FLOATATION CELL	50(2)015	02	BARBER	2" 520			BORE .875" [illegible]	
	FI-82			02	ROSEMOUNT	1151DPS			[illegible]	
	FIC-82			02					DCS	
	FY-82			02	FISHER	546			[illegible]	
	FV-82			02	FISHER	2" 667D				
	NY-82								DCS MULTIPLIER	

NO	REVISION	BY	DATE	CKD

CUSTOMER: ENERGY MINES & RESOURCES
PROJECT: COAL FROTH FLOATATION

kenonic controls ltd.
CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE
DRWN
CHKD
DWG NO
REV
DATE
APPD
SHT 1 OF

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	FE-83	AIR TO FLOATATION CELL	50(2)016	02	BARBER	2-520			[illegible]	
	FT-83			02	ROSEMOUNT	1151DP5			[illegible]	
	FIC-83			02					DCS	
	FY-83			02	FISHER	546			[illegible]	
	FV-83			02	FISHER	2" 667D				
	NY-83			02					DCS MULTIPLIER	
	FE-120	TAILINGS COAL/WATER SLURRY		02	FOXBORO	2802-SABA LSAG			[illegible]	
	FT-120			02	FOXBORO	E96T-IA				
	FI-120			02					DCS	
	FI-84	AIR TO CELL # 1		02	FISCHER & PORTER	10A3555A			ROTAMETER	
	FI-85	AIR TO CELL # 2		02	FISCHER & PORTER	10A3555A			ROTAMETER	
	FI-86	AIR TO CELL # 3		02	FISCHER & PORTER	10A3555A			ROTAMETER	
	FI-87	AIR TO CELL # 4		02	FISCHER & PORTER	10A3555A			ROTAMETER	
	FI-88	AIR TO CELL # 5		02	FISCHER & PORTER	10A3555A			ROTAMETER	
	FI-89	AIR TO CELL # 6		02	FISCHER & PORTER	10A3555A			ROTAMETER	

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOATATION

kenonic controls ltd.
CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE FLOW

DRAWN [illegible] CHKD
DATE [illegible] APPD
DWG NO
SHT 2 OF
REV

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	FFIC-60	FROTHER INJECTION RATE		02					DCS	
	FY-60		6(25)007	02	[illegible]	FR2102 [illegible]			[illegible]	
	FFIC-61	COLLECTOR INJECTION RATE	[illegible]	02					DCS	
	FY-61			02	[illegible]	[illegible]			[illegible]	

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOTATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE FLOW

DRWN [illegible] CHKD

DATE [illegible] APPD

DWG NO [illegible]

SHT 3 OF [illegible]

REV [illegible]

REV	TAG NO.	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	LE-40	FINES TANK 4056	4056	02	BROOKS				BUBBLER SYSTEM	
	LT-40			02	ROSEMOUNT	1151DP4				
	LIC-40A			02					DCS	
	LIC-40B			02					DCS	
	LE-11	FLOATATION CELL LEVEL	4113	02	—				EXISTING [illegible]	
	LT-11			02	ROSEMOUNT	1151DP4				
	LIC-11			02					DCS	
	LY-11			02	FISHER	546			[illegible]	
	LV-11			02	—				EXISTING	
	LE-12	FLOATATION CELL LEVEL	4113	02	—				EXISTING	
	LT 12			02	ROSEMOUNT	1151DP4				
	LIC-12			02					[illegible]	
	LY-12			02	FISHER	546			[illegible]	
	LV-12			02	—				EXISTING	

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOTATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE LEVEL

DRWN RP
DATE
CHKD
APPD
DWG NO
SHT 4 OF
REV

REV	TAG NO.	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	DT-30	COAL / WATER SLURRY DENSITY	76(3)EX	02					[illegible]	
	DI-30			02					DCS	
	NY-30			02					DCS MANUAL STATION	
	DIC-30			02					DCS	
	DY-30			02					DCS LOW SELECT	
	DY-30			02	FISHER	546			I/P [illegible]	
	DV-30		50(2)009	02	FISHER	2" 667D				
	DT-110	FEED ASH DENSITY	76(3)002	02	[illegible]	[illegible]				
	DI-110			02					DCS	
	DT-130	TAILINGS ASH DENSITY	76(3)022	02	[illegible]	[illegible]				
	DI-130			02					DCS	
	AE-1	SLURRY PH	76(3)EX	02	ROSEMOUNT	[illegible]			[illegible]	
	AT-1			02	ROSEMOUNT	1050A-02-07-11				
	AI-1			02					DCS	
	AT-110	FEED ASH ANALYZER	76(3)002		[illegible]	[illegible]			[illegible]	
	NY-8								[illegible]	

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL [illegible]

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE ANALYTICAL

DRWN
CHKD
DWG NO
REV
DATE
APPD
SHT 5 OF

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	AT-130 AI-130	TAILINGS ASH ANALYZER	76(3)022	02	NATIONAL [illegible]	[illegible] [illegible]			[illegible] DCS	

NO.	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOTATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE ANALYTICAL

DRWN [illegible] CHKD

DATE [illegible] APPD

DWG NO

SHT [illegible] OF [illegible]

REV [illegible]

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	JT-71	POWER FLOATATION CELL MIXER MOTOR #1	4113		[illegible]	[illegible]			[illegible]	
	JT-73	POWER FLOATATION CELL MIXER MOTOR #2	4113		[illegible]	[illegible]			[illegible]	
	JT-75	POWER FLOATATION CELL MIXER MOTOR #3	4113							

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOATATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE POWER

DRWN [illegible]

CHKD

DATE [illegible]

APPD

DWG NO

SHT 2 OF [illegible]

REV [illegible]

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	SIC-92	FLOATATION CELL MOTOR #1	4113	02	TO: USA	VT130G1-40[illegible]				
	SI 92			02						
	NIC-92	S.P. POWER CONTROL		02						
	SIC-94	FLOATATION CELL MOTOR #2	4113	02	[illegible]	[illegible]				
	SI-94			02						
	NIC-94	S.P. POWER CONTROL		02						
	SIC-96	FLOATATION CELL MOTOR #3	4113	02	[illegible]	[illegible]				
	SI-96			[illegible]						
	NIC-96	S.P. POWER CONTROL		[illegible]						
	SIC-10	WATER/COAL SLURRY PUMP		02	[illegible] USA	VT130G1-[illegible]				

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOATATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE SPEED CONTROL

DRWN ___ CHKD ___ DWG NO ___ REV

DATE ___ APPD ___ SHT 5 OF ___

REV	TAG NO.	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG
	FIY-1	MASS FLOW OF SOLIDS		02					DCS	
	FIY-2	MASS FLOW OF COAL		02					DCS	
	FIY-3	MASS FLOW OF SOLIDS		02					DCS	
	FIY-4	MASS FLOW OF COAL		02					DCS	
	FIY-5	GRADE		02					DCS	
	FIY-6	RECOVERY		02					DCS	
	NY-9	ASH TO Sg. TABLE		02					DCS [illegible]	
		NOTE: FOR FIY1 THROUGH FIY 6 SEE FORMULAS ON P&ID - 02								

NO	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOTATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE MASS FLOW CALC

DRWN
CHKD
DWG NO
REV
DATE
APPD
SHT 1 OF

REV	TAG NO	SERVICE	EQUIPMENT OR LINE #	MFS #	MANUFACTURER	INST MODEL #	PURCHASE ORDER NO	SHEET NO	NOTES	CONN. DWG.
	PCV- 80	AIR TO DISTRIBUTION HEADER	65(2.5)010	02	FISHER	1"-630			SET [illegible]	
	PI- 80	AIR DISTRIBUTION HEADER	65(2.5)010	02	HYDROPOISE	901				

NO.	REVISION	BY	DATE	CKD

CUSTOMER ENERGY MINES & RESOURCES

PROJECT COAL FROTH FLOTATION

kenonic controls ltd.

CALGARY ALBERTA EDMONTON

INSTRUMENT INDEX

INSTRUMENT TYPE PRESSURE

DRWN [illegible] CHKD

DATE [illegible] APPD

DWG NO [illegible]

SHT [illegible] OF [illegible]

REV [illegible]

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

CONTROL VALVES

NO	BY	DATE	REVISION

SHEET 1 OF 2

SPEC. NO. V-01	REV. 0
CONTRACT 3333	DATE 22/1/85
REQ. - P.O.	

BY	CHK'D	APPR.
RP		

GENERAL	1.	Tag No.		FV-10		FV-81		FV-82		FV-83	
	2.	Service		SLURRY DRAIN		AIR TO FLOATATION CELL		AIR TO FLOATATION CELL		AIR TO FLOATATION CELL	
	3.	Line No./Vessel No.		76 EX		50(2)011		50(2)012		50(2)013	
	4.	Line Size/Sched. No.		76MM / 40		50MM / 40		50MM / 40		50MM/40	
BODY	5.	Type of Body		V-BALL		GLOBE		GLOBE		GLOBE	
	6.	Body Size	Port Size	25MM	25MM	25MM	12MM	25MM	12MM	25MM	12MM
	7.	Guiding	No. of Ports	SIDE	ONE	TOP	ONE	TOP	ONE	TOP	ONE
	8.	End Conn. & Rating		150 FF FLNG		150# RF FLNG		150# RF FLNG		150# RF FLNG	
	9.	Body Material		CARBON STEEL		CARBON STEEL		CARBON STEEL		CARBON STEEL	
	10.	Packing Material		TEFLON		TEFLON		TEFLON		TEFLON	
	11.	Lubricator	Isolating Valve	—	—	—	—	—	—	—	—
	12.	Bonnet Type		MFG. STD.		SCREWED		SCREWED		SCREWED	
	13.	Trim Form		LINEAR		EQUAL %		EQUAL %		EQUAL %	
	14.	Trim Material	Seat/Plug	316 SS		316 SS		316 SS		316 SS	
			Shaft Mtl.	316 SS		316 SS		316 SS		316 SS	
	15.	Required Seat Tightness		CLASS IV		CLASS IV		CLASS IV		CLASS IV	
	16.	Max. Allow., Sound Level dBA		—							
ACTUATOR	17.	Model No. & Size		1051 / 30		667 / 30		667 / 30		667/30	
	18.	Type of Actuator		DIAPHRAGM		DIAPHRAGM		DIAPHRAGM		DIAPHRAGM	
	19.	Close at	Open at	100 KPA	20 KPA	20 KPA	100 KPA	20 KPA	100 KPA	20 KPA	100 KPA
	20.	Flow Action to		—		CLOSE		CLOSE		CLOSE	
	21.	Fail Position		OPEN		CLOSE		CLOSE		CLOSE	
	22.	Handwheel & Location		—		—		—		—	
POSIT.	23.	MFR. & Model No.		—		—		—		—	
	24.	Filt. Reg.	Gages / Bypass	— — —		— — —		— — —		— — —	
	25.	Input Signal		—		—		—		—	
	26.	Output Signal		—		—		—		—	
	27.	Air Supply Pressure		—		—		—		—	
TRANSDUCER FY-81, 82, 83	28.	Make & Model No.		—		FISHER 546		FISHER 546		FISHER 546	
	29.	Input Signal		—		4-20 MA		4-20 MA		4-20 MA	
	30.	Output Signal		—		20-100 KPA		20-100 KPA		20-100 KPA	
OPTIONS	31.	SOLENOID (24VDC)		832058		—		—		—	
	32.										
	33.										
SERVICE	34.	FLOW UNITS		LIQUID		STEAM		GAS			
	35.	Fluid		SLURRY		AIR		AIR		AIR	
	36.	Quant. Max.	C_v	—	—	40 l/s	70	40 l/s	70	40 l/s	70
	37.	Quant. Oper.	C_v	—	—	28 l/s	38	28 l/s	38	28 l/s	38
	38.	Valve C_v	Valve F_L	22.3	—						
	39.	Norm. Inlet Press.	ΔP	118 KPA	110 KPA	420 KPA	360 KPA	420 KPA	360 KPA	420 KPA	360 KPA
	40.	Max. Inlet Press.		118 KPA		1050 KPA		1050 KPA		1050 KPA	
	41.	Max. Shut Off ΔP		118 KPA		1050 KPA		1050 KPA		1050 KPA	
	42.	Temp. Max.	Operating	AMB	AMB	AMB	AMB	AMB	AMB	AMB	AMB
	43.	Oper. sp. gr.	Mol. Wt.	1.3-2.6	—	1	29	1	29	1	29
	44.	Oper. Visc.	% Flash	—	—	—	—	—	—	—	—
	45.	% Superheat	% Solids	—	15%	—	0%	—	0%	—	0%
	46.	Vapor Press.	Crit. Press.	—	—	—	—	—	—	—	—
	47.	Predicted Sound Level dBA		—							
	48.	Manufacturer		FISHER		FISHER		FISHER		FISHER	
	49.	Model No.		1" 1052-V100		2" 667D		2" 667D		2" 667D	

Notes

ISA FORM S20.50

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

CONTROL VALVES

NO	BY	DATE	REVISION

SHEET 2 OF 2

SPEC. NO. V-01	REV. 0
CONTRACT 3333	DATE 23/1/85
REQ. - P.O.	

BY	CHK'D	APPR.
RP		

GENERAL	1.	Tag No.	LV-11	LV-12	DV-30	
	2.	Service	FLOATION CELL LEVEL CONTROL	FLOATATION CELL LEVEL CONTROL	CLARIFIED H2O TO SLURRY	
	3.	Line No./Vessel No.			50(2)009	
	4.	Line Size/Sched. No.			50MM/40	
BODY	5.	Type of Body			GLOBE	
	6.	Body Size Port Size			50MM 12MM	
	7.	Guiding No. of Ports			TOP ONE	
	8.	End Conn. & Rating			150# RF FLNG.	
	9.	Body Material			C. STEEL	
	10.	Packing Material			TEFLON	
	11.	Lubricator Isolating Valve			— —	
	12.	Bonnet Type			SCREWED	
	13.	Trim Form	NOTE 1	NOTE 1	EQUAL %	
	14.	Trim Material Seat/Plug			316SS	
		Shaft Mtl.			316SS	
	15.	Required Seat Tightness			CLASS IV	
	16.	Max. Allow., Sound Level dBA			—	
ACTUATOR	17.	Model No. & Size			667/30	
	18.	Type of Actuator			DIAPHRAGM	
	19.	Close at Open at			20KPA 100KPA	
	20.	Flow Action to			CLOSE	
	21.	Fail Position			CLOSE	
	22.	Handwheel & Location			—	
POSIT.	23.	MFR. & Model No.			—	
	24.	Filt. Reg. Gages Bypass			— — —	
	25.	Input Signal			—	
	26.	Output Signal			—	
	27.	Air Supply Pressure			—	
TRANS DUCER LY 11,12 DY30	28.	Make & Model No.	FISHER 546	FISHER 546	FISHER 546	
	29.	Input Signal	4-20MA	4-20MA	4-20MA	
	30.	Output Signal	20-100KPA	20-100KPA	20-100KPA	
OPTIONS	31.		67FR	67FR	67FR	
	32.					
	33.					
SERVICE	34.	FLOW UNITS	LIQUID	STEAM	GAS	
	35.	Fluid			WATER	
	36.	Quant. Max. Cv			3.33 l/s 2.3	
	37.	Quant. Oper. Cv			0 l/s —	
	38.	Valve Cv Valve FL			6.82 .65	
	39.	Norm. Inlet Press. ΔP			85 KPA 65KPA	
	40.	Max. Inlet Press.			350 KPA	
	41.	Max. Shut Off ΔP			350 KPA	
	42.	Temp. Max. Operating			AMB AMB	
	43.	Oper. sp. gr. Mol. Wt.			1 —	
	44.	Oper. Visc. % Flash			1cP —	
	45.	% Superheat % Solids			— —	
	46.	Vapor Press. Crit. Press.			3209psi —	
	47.	Predicted Sound Level dBA			—	
	48.	Manufacturer			FISHER	
	49.	Model No.			2" 667D	

Notes 1) VALVES ARE EXISTING, TRANSDUCERS ONLY ARE REQUIRED.

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

PRESSURE CONTROL VALVES PILOTS and REGULATORS

NO	BY	DATE	REVISION

SHEET 1 OF 1	
SPEC. NO. P-02	REV. 0
CONTRACT 3333	DATE 23/1/84
REQ.	P.O.
BY RP	CHK'D	APPR.

GENERAL	1.	Tag No.		PCV- 80				
	2.	Service		AIR TO DIST. HEADER				
	3.	Line No./Vessel No.		65(25)010				
	4.	Line Size/Sched. No.		65MM / 40				
	5.	Function		PRESS CONT.				
BODY	6.	Type of Body		GLOBE				
	7.	Body Size	Port Size	2"	1/2"			
	8.	Guiding	No. of Ports	TOP	ONE			
	9.	End Conn. & Rating		50MM NPT				
	10.	Body Material		CARBON STEEL				
	11.	Packing Material						
	12.	Lubricator	Iso. Valve	—	—			
	13.	Seal Type		—				
	14.	Trim Form		QUICK OPEN				
	15.	Trim Material		BRASS				
	16.	Seat Material		BRASS				
	17.	Required Seat Tightness		—				
	18.	Max. Allow Sound Level dBA		—				
ACTUATOR/ PILOT	19.	Type of Actuator		DIAPHRAGM				
	20.	Pilot		BRASS				
	21.	Supply to Pilot		DOWNSTREAM				
	22.	Self Cont.	Ext. Conn.	YES	—			
	23.	Diaphragm Material		NEOPRENE/NYLON				
	24.	Diaphragm Rating		655 KPA				
	25.	Spring Range		310KPA → 655KPA				
	26.	Set Point		420 KPA				
	27.							
ACCESSORIES	28.	Filt. Reg.	Supply Gage					
	29.	Line Strainer						
	30.	Housing Vent						
	31.	Internal Relief						
	32.							
	33.							
SERVICE	34.	FLOW UNITS		LIQUID		STEAM		GAS
	35.	Fluid		AIR				
	36.	Quant. Max.	Cv	120 l/s				
	37.	Quant. Oper.	Cv	97 l/s				
	38.	Valve [illegible]	Valve FL	150 l/s				
	39.	Norm. Inlet Press.	ΔP	1050 KPA	620 KPA			
	40.	Max. Inlet Press.		1050 KPA				
	41.	Max. Shut Off	ΔP	1050 KPA	1050 KPA			
	42.	Temp. Max.	Operating	AMB	AMB			
	43.	Oper. sp. gr.	Mol. Wt.	1	29			
	44.	Oper Visc.	% Flash	.017	—			
	45.	% Superheat	% Solids	—	0%			
	46.	Vapor Press.	Crit. Press.					
	47.	Predicted Sound Level dBA						
	48.	Manufacturer		FISHER				
	49.	Model No.		630				

Notes:

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

MAGNETIC FLOWMETERS

NO	BY	DATE	REVISION

SHEET 1 OF 1

SPEC. NO. F-01

REV. 0

CONTRACT

DATE 22/1/85

REQ. - P.O.

BY RP

CHK'D

APPR.

	1	Meter Tag No.		FE-10		FE-120					
	2	Service		COAL/WATER SLURRY		TAILINGS FLOW					
	3	Location									
METERING ELEMENT	4	CONN'S.	Line Size, Sched.	50MM/40		50MM/40					
	5		Line Material	PVC		PVC					
	6		Connection Type	150# FF FLNG		150# FF FLNG					
	7		Connection Mat'ls.	316 SS		316 SS					
	8	METER	Tube Material	300 SERIES SS		300 SERIES SS					
	9		Liner Material	PTFE		PTFE					
	10		Electrode Type	MFG. STD.		MFG STD					
	11		Electrode Matl.	316 SS		316 SS					
	12		Meter Casing	MFG. STD.		MFG STD					
	13		Power Supply | Elect. Code	110VAC	NEMA 4	110VAC	NEMA 4				
	14		Grounding, Type & Matl.	GROUND RINGS		GROUND RINGS					
	15		Enclosure Class	NEMA 4		NEMA 4					
	16										
	17	FLUID	Fluid	SLURRY		SLURRY					
	18		Max. Flow, Units	500 L/M		500 L/M					
	19		Max. Velocity, Units								
	20		Norm. Flow | Min. Flow		250 L/M		250 L/M				
	21		Max. Temp. | Min. Temp.	AMB	—	AMB	—				
	22		Max. Press. | Min. Press.	118 KPA	—	145 KPA	—				
	23		Min. Fluid Conductivity	H_2O		H_2O					
	24		Vacuum Possibility	NIL		NIL					
	25										
ASSOCIATED INSTRUMENT	26	Instrument Tag Number		FT-10		FT-120					
	27	Function		TRANSMITTER		TRANSMITTER					
	28	Mounting		LOCAL		LOCAL					
	29	Enclosure Class		NEMA 4		NEMA 4					
	30	Length Signal Cable		20'		20'					
	31	Type Span Adjustment		MFG. STD.		MFG STD.					
	32	Power Supply		120 VAC		120 VAC					
	33	TRANS.	Transmitter Output	4-20 MADC		4-20 MADC					
	34										
	35	DISPLAY	Scale Size | Range	MFG STD	0-100%	MFG. STD	0-100%				
	36		Chart Drive | Speed	N/A	N/A	N/A	N/A				
	37		Chart Range | Chart No.	N/A	N/A	N/A	N/A				
	38		Integrator	NO		NO					
	39	CONTR.	Modes | Output	—	—	—	—				
	40		Action | Auto-Man.	—	—	—	—				
	41										
	42	ALARM	Contact No. | Form	—	—	—	—				
	43		Rating | Elec. Code	—	—	—	—				
	44		Action	—		—					
	45	Manufacturer		FOXBORO		FOXBORO					
	46	Meter Model Number		2802-SABA-ISA 6		2802-SABA-ISA 6					
	47	Instrument Model Number		896-SA-A		896-SA-A					

Notes:

Pulsed DC type meter with transmitter 2 required. Alternate for FE & FT {FISCHER PORTER FISCHER PORTER B10D1465 AB12PB21AC12CA}

ISA FORM S20.23

INSTRUMENT SPECIFICATIONS

ENERGY MINES & RESOURCES
COAL FROTH FLOATATION
CONTROL SYSTEM

NO.	BY DATE	REVISION
△		
△		
△		
△		
△		
△		

SHEET NO. 1-1
REV. 0
DATE 24/1/85
CONTRACT 3333
MANUFACTURER
SPEC A-01
BY RP
CHK'D
APPR'D

ALL ITEMS SHALL COMPLY WITH GENERAL SPECIFICATION SHEETS

1. TYPE ☐ ELECTRONIC ☒ PNEUMATIC ☐
2. TYPE OF DEVICE P.H. ANALYZER
3. FUNCTION WATER/COAL SLURRY PH
4. SCALING
5. MOUNTING FLUSH ☐ SURFACE ☐ RELAY RACK ☐
OTHER LOCAL
6. ELECTRICAL CLASS. NEMA 4X
7. CONDUIT CONN.
8. AIR CONNECTION 1/4" NPT ☐ OTHER N/A
9. MFR. MODEL NO. ROSEMOUNT
TRANSMITTER - 1050A-02-07-11
SENSOR 391PH-03-12-20-20-40-50

10. INPUT SIGNAL 4-20MA ☐ 3-15 PSIG ☐
OTHER N/A
11. INPUT FORM LINEAR ☐ SQUARED ☐
12. INPUT RESISTANCE OHMS
13. OUTPUT SIGNAL 4-20MA ☒ 3-15 PSIG ☐
OTHER
14. POWER SUPPLY 24 VOLTS DC HZ
15. AIR SUPPLY 20 PSIG ☐ OTHER N/A
ACCESSORIES
16. FILTER REGULATOR N/A
17. SUPPLY GAUGE N/A
18. OTHER

REV	QTY	TAG NO.	SERVICE OR REMARKS	FLOWSHEET & FRAME NO.	NOTES
		AE-1	PH SENSOR		
			2" FLOW TROUGH, RUGEDIZED TEMP		
			COMPENSATED (STD), INTEGRAL		
			PRE AMP		
		AT-1	PH TRANSMITTER		
			STANDARD CONSTRUCTION,		
			4-20 MA NON ISOLATED OUTPUT		
			2" PIPE WALL MOUNT BRACKET		
			S.S. [illegible]		

NOTES

21.1

FOR OUTLINE DIMENSIONS SEE CATALOG ☐ CERTIFIED PRINT ☐

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

TURBINE FLOWMETERS

NO	BY	DATE	REVISION

SHEET 1 OF 1

SPEC. NO. F-02	REV. 0
CONTRACT	DATE 22/1/85
REQ. - P.O.	

BY	CHK'D	APPR.
RP		

METER	1	Tag Number	FE - 20			
	2	Service	CLARIFIED WATER			
	3	Meter Location				
	4	Line Size	50 MM			
	5	End Connections	150# RF FLNG			
	6	Body Rating	150# ANSI			
	7	Nominal Flow Range	35-216 L/M			
	8	Accuracy	± .5 %			
	9	Linearity	± .25 %			
	10	K Factor, Cycles per Vol. Unit	666.7 P/L			
	11	Excitation	PULSE			
	12	Materials: Body	304 SS			
	13	Support	304 SS			
	14	Shaft	TUNGSTON CARBIDE			
	15	Flanges	304 SS			
	16	Rotor	400F SS			
	17	Bearings: Type	440C SS BALL			
	18	Bearing Material	TUNGSTON CARBIDE			
	19	Max. Speed	500 HZ			
	20	Min. Output Voltage	—			
	21	Pickoff Type	MAGNETIC			
	22	Enclosure Class	NEMA 4			
	23					
FLUID DATA	24	Fluid				
	25	Flow Rate Min. | Max.	0 L/M | 200 L/M			
	26	Normal Flow	—			
	27	Operating Pressure	120 KPA			
	28	Back Pressure	115 KPA			
	29	Operating Temp. Max. | Min	AMB | —			
	30	Operating Specific Gravity	1			
	31	Viscosity Range	—			
	32	Percent Solids & Type	—			
	33					
SECONDARY INSTR.	34	Secondary Instr. Tag No.	FT - 20			
	35	Preamplifier	YES			
	36	Function	TRANSMITTER			
	37	Mounting	PANEL			
	38	Power Supply	120 VAC			
	39	Scale Range	0 - 200 L/M			
	40	Output Range	4 - 20 MA			
OPTIONS	41	Totalizer Type				
	42	Compensation				
	43	Preset Counter				
	44	Enclosure Class				
	45	Strainer Size & Mesh				
	46					
	47					
	48					
	49	Manufacturer	FTI			
	50	Meter Model No.	FT16CX60LBS			
	51	Secondary Instr. Model No.	SR-1AA3BM			

Notes:

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

ORIFICE PLATES and FLANGES

NO	BY	DATE	REVISION

SHEET 1 OF 1

SPEC. NO.	REV.
F-04	0
CONTRACT	**DATE**
3333	23/1/85

REQ. - P.O.

BY	CHK'D	APPR.
RP		

ORIFICE PLATES

1. Concentric ☒ Other
2. ISA Standard ☒ Other
3. Bore: Maximum Rate ☐ Nearest 1/8 in. ☒
4. Material: 304SS ☐ 316SS ☒ Other
5. Ring Material & Type
6. MFR. & Model No.

ORIFICE FLANGES

7. Taps: Flange ☒ Vena Contracta ☐ Pipe ☐ Other
8. Tap Size: 1/2 in. ☒ Other
9. Type: Weld Neck ☒ Slip On ☐ Threaded ☐
10. Material: Steel ☒ Other
11. Flanges included ☒ By others ☐
12. Flange Rating 150 # RF

FLUID DATA	13	Tag Number	FE - 81	FE - 82	FE - 83	
	14	Service	AIR TO FLOATATION CELL	AIR TO FLOATATION CELL	AIR TO FLOATATION CELL	
	15	Line Number	50(2)014	50(2)015	50(2)016	
	16	Fluid	AIR	AIR	AIR	
	17	Fluid State	GAS	GAS	GAS	
	18	Maximum Flow	40 l/s	40 l/s	40 l/s	
	19	Normal Flow	28 l/s	28 l/s	28 l/s	
	20	Pressure	27.5 KPA	27.5 KPA	27.5 KPA	
	21	Temperature	AMB.	AMB	AMB	
	22	Specific Gravity at Base	1.0	1.0	1.0	
	23	Operating Spec. Gravity	1.0	1.0	1.0	
	24	Supercomp. Factor	1.0	1.0	1.0	
	25	Mol. Weight / Cp/Cv	29 /	29 /	29 /	
	26	Operating Viscosity	.017	.017	.017	
	27	Quality % or °Superheat	—	—	—	
	28	Base Press. / Base Temp.	95.85KPA / 15.6°C	98.85KPA / 15.6°C	98.85KPA / 15.6°C	
METER	29	Type of Meter	FLOW	FLOW	FLOW	
	30	Diff. Range – Dry	25 KPA	25 KPA	25 KPA	
	31	Seal sp. gr. at 60° F	—	—	—	
	32	Static Press. Range	—	—	—	
	33	Chart or Scale Range	—	—	—	
	34	Chart Multiplier	—	—	—	
PLATE & FLANGE	35	Beta=d/D	.4233199	.4233199	.4233199	
	36	Orifice Bore Diameter	.875"	.875"	.875"	
	37	Line I.D.	2.067"	2.067"	2.067"	
	38	Flange Rating	150#	150#	150#	
	39	Vent or Drain Hole	N/A	N/A	N/A	
	40	Plate Thickness	1/8"	1/8"	1/8"	

Notes: L/S x 2.11888 = ft³/MIN x 60 = ft³/HR

ISA FORM S20-21

```
                                     NO|BY |DATE      | SHEET: 1  OF  1
       ORIFICE PLATES & FLANGES      --|---|----------| SPEC#:F-04    REV: 0
                                       |   |          | JOB #:1468
ENERGY MINES RESOURCES                 |   |          | P.O. :
COAL FROTH FLOTATION                   |   |          | DATE:23/1/85  CHK:
                                       |   |          | BY   :RP      APR:
==============================================================================
ORIFICE PLATES      1.   ORIFICE PLATE      : CONCENTRIC
                    2.   STANDARD           : ISA
                    3.   BORE               : ROUNDED BORE
                    4.   MATERIAL           : 316 SS
                    5.   RING MATERIAL      : 301 SS
                    6.   RING TYPE          :
                    7.   MANUFACTURER       : BARBER
                    14.  MODEL NUMBER       : 520
------------------------------------------------------------------------------
ORIFICE FLANGES     8.   TAPS               : O.P.-FLG.TAPS
                    9.   TAP SIZE           : 1/2 "
                    10.  TYPE               : WELD NECK
                    11.  MATERIAL           : CARBON STEEL
                    12.  FLANGES INCLD.     : YES
                    13.  FLANGE RATING      : 150#
------------------------------------------------------------------------------
FLUID DATA          15.  TAG NUMBER         : FE-81
                    16.  SERVICE            : AIR TO FLOATION CELL #1
                    17.  LINE NUMBER        : 50(2)015
                    18.  FLUID              : AIR
                    19.  FLUID STATE        : GAS (General)
                    20.  MAXIMUM FLOW       : 6635.622        SCFH
                    21.  NORMAL FLOW        : 3560            SCFH
                    22.  PRESSURE           : 4               PSIG
                    23.  TEMPERATURE        : 60              DEG.F
                    24.  S.G. @ BASE        : 1.000
                    25.  OPER. S.G.         :
                    26.  Z FACTOR           : 1.000
                    27.  WGHT. | CP/CV      : .00000  | 1.400
                    28.  OPER. VISC.        : .01700
                    29.  QLTY / SUPHEAT     :
                    30.  BASE  PRES|TEMP    :
------------------------------------------------------------------------------
METER               31.  TYPE OF METER      : DRY
                    32.  DIFF RANGE         : 100             IN-H20
                    33.  SEAL S.G.          :
                    34.  STATIC PRESS.      :
                    35.  CHART/SCALE        :
                    36.  CHART MULT.        : 158.1704
------------------------------------------------------------------------------
PLATE &             37.  BETA=d/D           : .4233188
FLANGE              38.  ORIFICE BORE       : .8750           IN
                    39.  LINE I.D.          : 2.067           IN
                    40.  FLANGE RATING      : 150#  RF
                    41.  VENT/DRAIN HOLE    :
                    42.  PLATE THICK.       : 1/8 IN          IN
                    43.  FLOWSHEET #        : 02
==============================================================================
NOTES               TYPICAL FOR FE-81/FE-82/FE-83
```

```
                                         NO|BY |DATE      | SHEET: 1  OF  1
         ORIFICE PLATES & FLANGES        --|---|----------| SPEC#:F-04    REV: 0
                                           |   |          | JOB #:1468
ENERGY MINES RESOURCES                     |   |          | P.O. :
COAL FROTH FLOTATION                       |   |          | DATE:23/1/85  CHK:
                                           |   |          | BY   :RP      APR:
==============================================================================
   Tag.No. : FE-81                        Eq./Line No.: 50(2)015
   Service : AIR TO FLOATION CELL #1      Flowsheet   : 02
 =============================================================================
   Manuf.  : BARBER                  Model No.   : 520
 =============================================================================
   ELEMENT DATA         Type             :    O.P.-FLG.TAPS
                        Press.Tap Loc.   :    N/A
                        Element Mat'l    :    316 SS
                        d/D ratio        :    .4233186
                        Element Bore     :    .875 IN
                        Thickness        :    1/8 IN
 -----------------------------------------------------------------------------
   SIZING CRITERIA      Sizing Mode      :    ROUNDED BORE
                        Reference        :    L.K.SPINK
 -----------------------------------------------------------------------------
   COEFFICIENTS         N   = 338.17               S   = .1096837
                        Fa  = .9998862             Fm  = 1
                        Fc  = 1.001138             Ym  = .9970626
                        Fpv = 1                    Ftf = 1
                        Fg  = 1
 =============================================================================
   PIPING DATA          Flange           :    2 IN 150# RF
                        Pipe Size & SCH:      2 IN 40
                        Pipe I.D.        :    2.067 IN
                        Flange Material:      CARBON STEEL
                        Pipe Material    :    CARBON STEEL
 =============================================================================
   PROCESS DATA    Fluid             :     AIR
                   Meter Diff.       :     100                  IN-H2O
                   Oper.Pressure     :     4                    PSIG
                   Oper.Temp.        :     60                   DEG.F
                   S.G. @ Std.Cond:        1
                   Sp.Ht.ratio (k):        1.4
                   Visc. @ Op.Cond:        .017                 CP
                   Atmos.Pressure :        13.6                 PSIA
                   Z - Factor        :     1
                   Normal Flow       :     3560                 SCFH
 =============================================================================
   METER DATA      Type              :     DRY
                   C' Coefficient :        158.1704
                   Full Scale Flow:        6635.622             SCFH
                   Flow reading      :     5.364984 (Normal)  Roots
 =============================================================================
   Notes :    1 .  TYPICAL FOR FE-81/FE-82/FE-83
```

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

DIFFERENTIAL PRESSURE INSTRUMENTS

NO	BY	DATE	REVISION

SHEET 1 OF 2

SPEC. NO. F-05	REV. 0
CONTRACT 3333	DATE 22/1/85
REQ. · P.O.	

BY	CHK'D	APPR.
RP		

	1	Tag No. SEE SPEC F-05 Pge 2 of 2	Service FLOW TRANSMISSION
GENERAL	2	Function	Record ☐ Indicate ☐ Control ☐ Blind ☐ Trans ■ Integ ☐ Other
	3	Case	MFR STD ■ Nom Size Color: MFR STD ■ Other
	4	Mounting	Flush ☐ Surface ☐ Yoke ■ Other
	5	Enclosure Class	General Purpose ☐ Weather proof ☐ Explosion proof ■ Class For use in Intrinsically Safe System ☐ Other
	6	Power Supply	117V 60 Hz ☐ Other ac dc ■ 24 Volts (SEE NOTE)
	7	Chart	12 in. Circ. ☐ Other N/A Range N/A No.
	8	Chart Drive	24 hr Other N/A Elec. ☐ Spring ☐ Other
	9	Scale	Type Range: 1 50KPA 2 3
XMTR	10	Transmitter Output	4-20 mA ■ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☐ Other For Receiver, See Spec Sheet
CONTROLLER	11	Control Modes	P=Prop (Gain), I=Integral (Auto Reset), D=Derivative (Rate) Sub: s=Slow, f=Fast I_f ☐ D_f ☐ P ☐ PI ☐ PD ☐ PID ☐ I_s ☐ D_s ☐ Other
	12	Action	On Meas. Increase Output: Increases ☐ Decreases ☐
	13	Auto-Man Switch	None ☐ MFR STD ☐ Other
	14	Set Point Adj.	Manual ☐ External ☐ Remote ☐ Other
	15	Manual Reg.	None ☐ MFR STD ☐ Other
	16	Output	4-20 mA ☐ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☐ Other
UNIT	17	Service	Flow ■ Level ☐ Diff. Pressure ☐ Other
	18	Element Type	Diaphragm ■ Bellows ☐ Mercury ☐ Other CAPACITANCE
	19	Material	Body CAD. PLATED C.S. Element 316 SS
	20	Rating	Overrange MFG STD Body Rating 2000 psig
	21	Diff. Range	Fixed ☐ Adj. Range 0-185 KPA Set At 0-25 KPA
	22		Elevation — Suppression -
	23	Process Data	Fluid AIR Max Temp. AMB Max. Press. 70 KPA
	24	Process Conn.	½ in. NPT ■ Other
	25	Alarm Switches	Quantity Form Rating
	26	Function	Meas. Var. ☐ Deviation ☐ Contacts To on Inc. Meas.
	27	Options	Pressure Element ☐ Range Material Temp. Element ☐ Range Type Filt Reg. ☐ Sup. Gage ☐ Output Gage ☐ Charts Valve Manifold ANDERSON GREENWOOD 3 VALVE Cond. Pots ☐ Adj. Damp ☐ Integral Sq. Rt. Ext. ☐ Integrator Other
	28	MFR & Model No.	ROSEMOUNT 1151DP5E12B1

Notes: NO SEPARATE POWER SUPPLY REQ'D.
(TWO WIRE TRANSMITTER)

ISA Form S20.20a

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

DIFFERENTIAL PRESSURE INSTRUMENTS

NO	BY	DATE	REVISION

SHEET 2 OF 2

SPEC. NO. F-05

REV. 0

CONTRACT 3333

DATE 22/11/85

REQ. - P.O.

BY RP

CHK'D

APPR.

Rev.	Tag	Adj. Range	Set Range	Scale or Chart	Scale Factor	Service	Notes
				—	—		
	FT- 81	0-50KPA	0-25KPA			AIR FLOW	
				—	—		
	FT- 82	0-50KPA	0-25KPA	—	—	AIR FLOW	
	FT- 83	0-50KPA	0-25KPA	—	—	AIR FLOW	

Notes:

ISA Form S20.20b

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

ROTAMETERS (VARIABLE AREA FLOWMETERS)

NO	BY	DATE	REVISION

SHEET 1 OF 2

SPEC. NO. F-06

REV. 0

CONTRACT 3333

DATE 23/1/85

REQ.

P.O.

BY RP

CHK'D

APPR.

GENERAL	1	Tag Number		FI-84		FI-85		FI-86		FI-87	
	2	Service		AIR TO FLOATATION CELL		AIR TO FLOATATION CELL		AIR TO FLOATATION CELL		AIR TO FLOATATION CELL	
	3	Line No./Vessel No.		50(2) 017		50(2) 017		50(2) 018		50(2) 018	
	4	Function		INDICATION		INDICATION		INDICATION		INDICATION	
	5	Mounting		IN LINE		IN LINE		IN LINE		IN LINE	
	6	Power Supply		—		—		—		—	
	7	Conn. Size	Type	3/4"	NPT	3/4"	NPT	3/4"	NPT	3/4"	NPT
	8	Inlet Dir.	Outlet Dir.	BTM	TOP	BTM	TOP	BTM	TOP	BTM	TOP
	9	Fitting Material		316SS		316SS		316 SS		316 SS	
	10	Packing or O-Ring Mtl.		TEFLON		TEFLON		TEFLON		TEFLON	
	11	Enclosure Type		—		—		—		—	
METER	12	Size	Float Guide	3/4"	TUBE	3/4"	TUBE	3/4"	TUBE	3/4"	TUBE
	13	Tube Mtl.	Float Mtl.	GLASS	316SS	GLASS	316SS	GLASS	316SS	GLASS	316SS
	14	Meter Scale: Length & Type									
	15	Meter Scale Range		0-20 SCFM		0-20 SCFM		0-20SCFM		0-20SCFM	
	16	Meter Factor		1		1		1		1	
	17	Rated Accuracy		± 2%		± 2%		± 2%		± 2%	
	18	Hydraulic Calib. Required		NO		NO		NO		NO	
FLUID DATA	19	Fluid		AIR		AIR		AIR		AIR	
	20	Color or Transparency		CLEAR		CLEAR		CLEAR		CLEAR	
	21	Maximum Flow Rate		20 SCFM		20 SCFM		20 SCFM		20 SCFM	
	22	Norm Flow	Min Flow	10SCFM	5SCFM	10 SCFM	5SCFM	10 SCFM	5SCFM	10SCFM	5SCFM
	23	Oper. Specific Gravity (Liq)		—		—		—		—	
	24	Max Oper. Viscosity		.017		.017		.017		.017	
	25	Oper. Press.	Oper. Temp.	20KPA	AMB	20KPA	AMB	20KPA	AMB	20KPA	AMB
	26	Oper. Density (Gases)		1		1		1		1	
	27	Std. Density	Mol. Wgt.	1	29	1	29	1	29	1	29
	28	Max. Allowable Press. Drop		35 KPA		35 KPA		35 KPA		35 KPA	
	29										
EXT	30	Extension Well Mtl.		—		—		—		—	
	31	Gasket Mtl.		TEFLON		TEFLON		TEFLON		TEFLON	
XMTR	32	Transmitter Output		—		—		—		—	
	33	Trans. Enclosure Class		—		—		—		—	
	34	Scale Range		—		—		—		—	
ALARM	35	No. of Contacts	Form	—	—	—	—	—	—	—	—
	36	Rating	Housing	—	—	—	—	—	—	—	—
	37	Action		—		—		—		—	
	38					—		—		—	
OPTIONS	39	Valve Size & Material		—		—		—		—	
	40	Valve Location		—		—		—		—	
	41	Const. Diff. Relay Mtl.		—		—		—		—	
	42	Purge Meter Tubing		—		—		—		—	
	43	Airset		—		—		—		—	
	43a										
	44	Manufacturer		FISCHER & PORTER		FISCHER & PORTER		FISCHER & PORTER		FISCHER & PORTER	
	45	Model Number		10A3555A		10A3555A		10A3555A		10A3555A	
	46	Tube Number		—							
	47	Float Number		—							

Notes:

ISA FORM S20.22

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

ROTAMETERS (VARIABLE AREA FLOWMETERS)

NO	BY	DATE	REVISION

SHEET 2 OF 2

SPEC. NO. F-06 REV. 0

CONTRACT 3333 DATE 23/1/85

REQ. P.O.

BY RP CHK'D APPR.

GENERAL	1	Tag Number		FI-88		FI-89			
	2	Service		AIR TO FLOATATION CELL		AIR TO FLOATATION CELL			
	3	Line No./Vessel No.		50(2) 019		50(2) 019			
	4	Function		INDICATION		INDICATION			
	5	Mounting		IN LINE		IN LINE			
	6	Power Supply		—		—			
	7	Conn. Size	Type	3/4"	NPT	3/4"	NPT		
	8	Inlet Dir.	Outlet Dir.	BTM	TOP	BTM	TOP		
	9	Fitting Material		316 ss		316 ss			
	10	Packing or O-Ring Mtl.		TEFLON		TEFLON			
	11	Enclosure Type		—		—			
METER	12	Size	Float Guide	3/4"	TUBE	3/4"	TUBE		
	13	Tube Mtl.	Float Mtl.	GLASS	316ss	GLASS	316ss		
	14	Meter Scale: Length & Type							
	15	Meter Scale Range		0 20 SCFM		0 - 20 SCFM			
	16	Meter Factor		1		1			
	17	Rated Accuracy		± 2%		± 2%			
	18	Hydraulic Calib. Required		NO		NO			
FLUID DATA	19	Fluid		AIR		AIR			
	20	Color or Transparency		CLEAR		CLEAR			
	21	Maximum Flow Rate		20 SCFM		20 SCFM			
	22	Norm Flow	Min Flow	10 SCFM	5 SCFM	10 SCFM	5 SCFM		
	23	Oper. Specific Gravity (Liq)		—		—			
	24	Max Oper. Viscosity		.017		.017			
	25	Oper. Press.	Oper. Temp.	10 KPA	AMB	10 KPA	AMB		
	26	Oper. Density (Gases)		1		1			
	27	Std. Density	Mol. Wgt.	1	29	1	29		
	28	Max. Allowable Press. Drop		35 KPA		35 KPA			
	29								
EXT	30	Extension Well Mtl.		—		—			
	31	Gasket Mtl.		TEFLON		TEFLON			
XMTR	32	Transmitter Output		—		—			
	33	Trans. Enclosure Class		—		—			
	34	Scale Range		—		—			
ALARM	35	No. of Contacts	Form	—	—	—	—		
	36	Rating	Housing	—	—	—	—		
	37	Action		—		—			
	38								
OPTIONS	39	Valve Size & Material		—		—			
	40	Valve Location		—		—			
	41	Const. Diff. Relay Mtl.		—		—			
	42	Purge Meter Tubing		—		—			
	43	Airset		—		—			
	43a								
	44	Manufacturer		FISCHER & PORTER		FISCHER & PORTER			
	45	Model Number		10A3555A		10A3555A			
	46	Tube Number		—		—			
	47	Float Number		—		—			

Notes:

ISA FORM S20.22

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

DIFFERENTIAL PRESSURE INSTRUMENTS

NO	BY	DATE	REVISION

SHEET 1 OF 2

SPEC. NO. L-01

REV 0

CONTRACT 3333

DATE 22/1/85

REQ. · P.O.

BY RP.

CHK'D

APPR.

	1	Tag No. SEE SPEC L-01 Pg 2 of 2	Service LEVEL TRANSMITTERS
GENERAL	2	Function	Record ☐ Indicate ☐ Control ☐ Blind ☐ Trans ☒ Integ ☐ Other
	3	Case	MFR STD ☒ Nom Size Color: MFR STD ☐ Other
	4	Mounting	Flush ☐ Surface ☐ Yoke ☒ Other
	5	Enclosure Class	General Purpose ☐ Weather proof ☐ Explosion proof ☒ Class For use in Intrinsically Safe System ☐ Other
	6	Power Supply	117V 60 Hz ☐ Other ac dc ☒ 24 Volts
	7	Chart	12 in. Circ. ☐ Other Range No.
	8	Chart Drive	24 hr Other Elec. ☐ Spring ☐ Other
	9	Scale	Type Range: 1 2 3
XMTR	10	Transmitter Output	4-20 mA ☒ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☐ Other For Receiver, See Spec Sheet
CONTROLLER	11	Control Modes	P=Prop (Gain), I=Integral (Auto Reset), D=Derivative (Rate) Sub: s=Slow, f=Fast If ☐ Df ☐ P ☐ PI ☐ PD ☐ PID ☐ Is ☐ Ds ☐ Other
	12	Action	On Meas. Increase Output: Increases ☐ Decreases ☐
	13	Auto-Man Switch	None ☐ MFR STD ☐ Other
	14	Set Point Adj.	Manual ☐ External ☐ Remote ☐ Other
	15	Manual Reg.	None ☐ MFR STD ☐ Other
	16	Output	4-20 mA ☐ 10-50 mA ☐ 21-103 kPa (3-15 psig) ☐ Other
UNIT	17	Service	Flow ☐ Level ☒ Diff. Pressure ☐ Other
	18	Element Type	Diaphragm ☒ Bellows ☐ Mercury ☐ Other
	19	Material	Body CAD. PLATE C.S. Element 316 SS
	20	Rating	Overrange 14 MPA Body Rating 14 MPA
	21	Diff. Range	Fixed ☐ Adj. Range 0-37.5 KPA Set At SEE Pg 2-2
	22		Elevation Suppression
	23	Process Data	Fluid WATER Max Temp. AMB Max. Press. ATM
	24	Process Conn.	½ in. NPT ☒ Other
	25	Alarm Switches	Quantity Form Rating
	26	Function	Meas. Var. ☐ Deviation ☐ Contacts To on Inc. Meas.
	27	Options	Pressure Element ☐ Range Material Temp. Element ☐ Range Type Filt Reg. ☐ Sup. Gage ☐ Output Gage ☐ Charts Valve Manifold Cond. Pots ☐ Adj. Damp ☐ Integral Sq. Rt. Ext. ☐ Integrator Other
	28	MFR & Model No.	ROSEMOUNT 1151DP4E12B1

Notes:

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

DIFFERENTIAL PRESSURE INSTRUMENTS

NO	BY	DATE	REVISION

SHEET 2 OF 2

SPEC. NO. L-01

REV. 0

CONTRACT 3333

DATE 22/1/85

REQ. - P.O.

BY RF

CHK'D

APPR.

Rev.	Tag	Adj. Range	Set Range	Scale or Chart	Scale Factor	Service	Notes
	LT-40	0-37.5KPA	0-17.5KPA	—	—	FINES TANK LEVEL	(1)
	LT-11	0-37.5KPA	0-15KPA	—	—	FLOATATION CELL	(2)
	LT-12	0-37.5KPA	0-15KPA	—	—	FLOATATION CELL	(2)

Notes: 1) BUBBLER SYSTEM REQUIRED - TO CONSIST OF ROTAMETER, REGULATOR, GAUGE, PIPING OR TUBING AS REQUIRED FITTINGS AS REQUIRED

2) EXISTING BUBBLER SYSTEM AVAILABLE.

ENERGY MINES & RESOURCES

COAL FROTH FLOATATION

CONTROL SYSTEM

PRESSURE GAGES

NO	BY	DATE	REVISION

SHEET 1 OF 1

SPEC. NO. P-01 REV. 0

CONTRACT 3333 DATE 23/1/85

REQ. P.O.

BY RP. CHK'D APPR.

1. Type: Direct Rdg ☒ 3-15 lb Receiver ☐
   Other
2. Mounting: Surface ☐ Local ☒ Flush ☐
3. Dial: Diameter Color
4. Case: Cast Iron ☐ Aluminum ☐ Phenol ☒
   Other
5. Ring: Screwed ☒ Hinged ☐ Slip ☐ Std ☐
   Other
6. Blow-out Protection None ☐ Back ☒ Disc ☐
   Solid Front ☐ Other
7. Lens: Glass ☐ Plastic ☒
8. Options: Sylphon ☐ Material
   Snubber ☐
   Pressure Limit Valve ☐
   Movement Damping ☐
9. Nominal Accuracy Required 1 %
10. MFR. & Model No. HYDROPOISE 901
11. Press. Element: Bourdon ☒ Bellows ☐
    Other
12. Element Mtl: Bronze ☐ Steel ☐ 316 SS
    Other
13. Socket Mtl: Bronze ☐ Steel ☒ SS
    Other
14. Connection-NPT: ¼ in. ☐ ½ in. ☒ Other
    Bottom ☐ Back ☐
15. Movement: Bronze ☐ SS ☒ Nylon ☐
    Other
16. Diaphragm Seal
    MFG. Type
    Wetted Part Mtl. Other Mtl.
    Fill Fluid
    Process Conn. Gage Conn.

Rev. Quan.	Tag No.	Range	Operating Pressure	Service
	PI-80	700 KPA	300 KPA	AIR TO FLOATATION CELLS

Notes:

ISA FORM S20.41a

4.0 IMPELLER SPEED CONTROL

4.1 Importance of Impeller Speed Control

Papers presented in Phase I discuss the importance of joint manipulation of air and impeller speed to cause changes in recovery and grade (Ref. 8). For example an increase in air causes an increase in recovery, but the same increasse in air if coupled with an increase in impeller speed gives a larger increase in recovery. Apparently the additional air is not utilized properly unless accompanied by an increase in impeller speed.

The designed control strategy manipulates impeller speed to restore power to a constant. An increase in air would cause a decrease in power. The speed would then be increased until power returns to its initial value.

4.2 Method of Impeller Speed Control

The existing 6 impellers are driven by 3 motors. Each motor is 5 HP and supply to the motors is 3 phase 480 V 60 Hz AC. Supply comes from 3 starters in the Motor Control Centre.

The speed of these 3 drive motors will be varied individually by 3 new variable frequency drivers.

The drive selected is Toshiba/Houston International Corporation ESP 130 series, model VT 130G1-4055. This variable speed drive accepts the existing 480 V 60 Hz AC power and provides an output of frequency range 3 to 80 Hz. This frequency will be varied in response to the process signal (4-20 ma) from each constant specific power controller. (NIC 92, NIC 94, NIC 96).

The existing induction motors will vary in speed to match (except for slip) this frequency.

4.3 Physical Installation

Each variable speed drive will be in a cabinet of size 915 h x 762 w x 254 d. (mm). (NEMA 12). These enclosures could be NEMA 1 if sufficient room is available inside the control room. If these enclosures are located outside the control room, which is the most likely case, NEMA 12 enclosures will be required. Sizes given are for NEMA 12.

These 3 variable speed drives can be located close to the motors, or preferably on the outside wall of the control room.

4.4 Electrical Installation

Power will come from the existing motor starters to the variable speed drive units. The existing motor starters can be used to disconnect the variable speed drives for service so no additional disconnect is required.

4.5 Method of Measuring Impeller Power

Three methods have been considered for obtaining a measurement representing impeller power. These are Torque, Amps, Watts.

4.5.1 Torque

Measuring the torque in the actual impeller shaft is the most direct and probably the best measurement to use in the control strategy.

A device to measure torque in a spinning shaft is manufactured by Brewer Engineering Laboratories in Marion MA, U.S.A. (See Appendix). This device uses strain gauges mounted on the rotating shaft and then brushes to pick up the signals from the rotating portion.

Unfortunately installation of such a device in the existing impellers would be complicated, involving one or perhaps two additional bearings so that the shaft could be split into an upper and a lower portion.

A design for such a change would have to be done using the detailed mechanical drawings of the manufacturer of the flotation cells. Such a design is beyond the current scope and should not be attempted unless other, simpler ways to measure power do not provide the desired results.

4.5.2 Amps

Motor amps will vary with motor load. A signal proportional to motor amps is available at a terminal of the Toshiba Frequency Speed Controllers. This signal can be directly accepted by the control system input.

Our recommendation is to use this available signal as the input noted on the P & ID as JT 71, JT 73, JT 75.

4.5.3 Watts

Another way to get an indication of motor power is by measuring watts. The equipment required to make this measurement would be:

Froth Flotation
Watts Measurement

Item	Qty.	Description
Current Transformers	6	Westinghouse Type ECI or KTI 100/5 ampere ratio, window type, 600 V, moulded type indoor application.
Voltage Transformers	6	Westinghouse Type PT-.6B 480-120 V, 600 V rating.
Watts Transducer	3	Westinghouse Type VP4-840. Input 0-5 amperes, 0-120 volts, for 3 phase, 3 wire service. Output 0-1.0 ma D.C. into 0-10,000 impedance.

4.0 IMPELLER SPEED CONTROL

This method of measuring power is our second choice and could be tried if the measurement of amps does not give accurate enough information for use in the control scheme (i.e. if amps change is not of a large enough magnitude to give good resolution).

Equipment to measure watts could be purchased and installed at much less cost than the cost to make mechanical modifications to the impellers in order to insert direct torque measurement devices.

4.5.4 Calculation of Specific Power

A mathematical expression for specific power was given in Phase II report and is noted as f(7) on the P & ID. We considered using this calculation of power instead of a measurement of power. The variables are:

QA	quantity of air - measured
N	impeller rpm - inferred from frequency
VLP	volume of liquid pulp - related to pulp level which is measured
ST	surface tension - not measured
DP	density of the pulp - measured only before the first cell.

There are also several constants and the values of these are not known.

Calculation of Specific Power is not a viable alternative to measuring power because the constants are not known.

5.0 CONTROLLERS AND OPERATOR INTERFACE

5.1 System Architecture

5.1.1 General

During Phase I of this project, Cambrian was given, by the Coal Research Lab a brief outline of the intended Pilot Plant Control System Architecture. The pages are in the Appendix for reference.

The item identified as Pilot Plant Computer (the HP 1000) was to have been located in the Pilot Plant Control Room. Presumably the intention was that this would be the operator interface. This plan has not been followed in two ways. (1) The heavy media micro processor identified on the first page has its own screen, keyboard and printer; in other words its own operator interface. (2) The Pilot Plant Computer has been located out of the control room in another part of the building, making it unavailable as an operator interface.

Instructions to Cambrian were to design for a system for froth flotation with its own screen and keyboard, thus its own operator interface. The systems proposed do this, but have a greater capability also. Looking beyond the froth flotation control project we see some system architecture problems, and our proposed system addresses and solves these problems, as well as providing the flotation control system requested. The problems and solutions are described in 5.1.2 and 5.1.3 below.

5.1.2 Future Problems

If a separate control system and a new operator interface is developed for each of the Pilot Plant sections the situation in the control room will be:

6 screens	6 keyboards
6 printers	6 processors

5.0 CONTROLLERS AND OPERATOR INTERFACE

The 6 systems would be for:

1. Heavy Media
2. Froth Flotation
3. Jig
4. Coarse Water Cyclones
5. Fine Water Cyclones
6. Thickener

In addition to 6 operator interfaces, each concerned with a particular section of the plant, there would be 6 places where analog inputs go, there would be 6 places where analog inputs come from, and there would be 7 places where digital inputs-outputs could be located. (The 6 above plus the PLC 2/30).

Besides being terribly confusing to operate and maintain, this amount of equipment would probably not fit in the existing control room. The pilot plant computer would be obtaining information from 7 different sources. No standard form has been prescribed so each of the 7 would possibly be in a different form.

Some alternate solution and some standardization is required or the control systems will be too cumbersome to work with after all 6 are installed.

5.1.2 Proposed Solution

The proposed solution to this problem is:

(a) Provide one operator interface that can be used for each and all of the planned systems. This would include one screen, one keyboard, one communicator and one mass storage device (hard disc). This would provide one location which would be one of only two locations required to communicate with the Pilot Plant Computer. (The other location being the PLC 2/30).

(b) Run all digital (on/off) signals to the PLC 2/30. This has been started but must be specified and insisted on. (Some digital input/output appears to go the to heavy media system now).

(c) Provide separate control modules for each of the 6 planned units. All analog input and output would go to these modules.

Physically each new module is a new printed process controller or set of process controllers as required for the process being controlled. Each new controller is from the same manufacturer as the flotation system. Likely one cabinet would have sufficient space for all 6 systems. Each system can run and control independently of the others even if the operator interface is not in service. A major added advantage is that each system can have access to values from the other systems.

(d) Future Contracts for Control System Design

Each future contract for design of a control system for a new portion of the pilot plant would require the selection of measuring instruments control devices and controllers to fit into an existing distributed control system. Configuration of the system to do the new functions would be required.

(e) Digital Inputs/Outputs (On/Off Signals)

An Allen Bradley PLC 2/30 has been installed. We have not seen a written description of what this control device is supposed to do in relation to what other control systems such as the Froth Flotation Control System are supposed to do. We have been told verbally approximately what the PLC is supposed to do. The PLC is supposed to conduct the sequential start up and shut down of the Pilot Plant. Further, within limits of the piping and valving (i.e. many valves are manual only) the PLC is supposed to start up the Pilot Plant in a certain way for a specific flow sheet option and start up the Pilot Plant in a different way for each different flow sheet option.

The operator interface to the PLC is at present just the programming panel. Something else may be planned.

From this verbal description we have formed the idea that most on/off signals are intended to come from and go to the PLC. This seems a reasonable approach, and can be valuable especially if it is made exclusive -i.e. all on/off signals go to and come from the PLC. PLC programs can look for and maintain proper sequencing and ensure that appropriate motors run together (or don't run together).

If this is the true intent of the PLC, then a logical step is to have a process control system which can access the PLC to determine which devices are on or off and to shut devices off if necessary.

The alternate is to have on/off signals individually input to the process control system as well as to the PLC. This would add a measure of confusion especially if some machines in the pilot plant become dual controlled - i.e. started and stopped by the PLC or by the Process Control System.

The Distributed Process Control System we recommend fulfills the requirements for floation process control and also can provide the operator interface for further control systems (Jig, Coarse Water Cyclones, Fine Water Cyclones, Thickener).

5.0 CONTROLLERS AND OPERATOR INTERFACE

5.1.3 Summary of System Architecture

(a) One Operator Interface (Screen, Keyboard, Printer, Communications)

(b) Individual Controllers for Pilot Plant Sections

(c) All Analog Input/Output to These Controllers

(d) Operator Interface does the only communications to Pilot Plant Computer (HP 1000)

(d) All Digital (On/Off) Input/Output to Allen Bradley PLC 2/30.

(f) Operator Interface communicates to PLC.

(g) Individual Controllers (b above) should be in as few cabinets as possible, perhaps one cabinet.

(h) Operator Interface and Controllers for Plant Sections all from one manufacturer, one model.

(i) Computer Modelling and other complex functions done by the Pilot Plant Computer.

5.2 Discussion of Systems for Froth Flotation Control

5.2.1 General

The systems considered are generally called, by their manufacturers, Distributed Control Systems. Their common characteristics are:

(a) The hardware that does the process control is broken into small sections which run independently of each other and can function individually. Small in this case means two to eight loops defining a loop as one analog output. These small controllers can be physically distributed from each other, or mounted close to each other but they remain functionally independent, which is the basis of the name Distributed Control.

(b) The operator interface is a CRT, keyboard communication, and mass storage (disk drive) device. Generally a printer is included. Controllers can be programmed (configured) from the operator interface. Controllers can be operated and tuned from the operator interface. (MAN/AUTO, SETPOINT ADJ, etc.).

Controllers configuration can be downloaded to the operator interface. New configurations can be developed and stored on the operator interface and uploaded to the controllers.

(c) Controllers can be individually locally configured, even if the operator interface is not in service.

(d) Configuration is done by selecting functions from an extensive list of available functions and answering required questions relating to the function chosen. The functions can be linked together and interrelated in a very flexible manner.

(e) The operator interface keyboard is not a typewriter-like keyboard, rather it is specifically designed for process control use.

(f) The operator interface can display information in many different ways including:

- individual loops,
- groups of loops,
- larger groups of loops,
- alarms.
- digital functions (on/off),
- trending,
- user drawn graphics.

These functions are pre-programmed and available to the user in a very easy to use way.

5.0 CONTROLLERS AND OPERATOR INTERFACE

These are the common characteristics of Distributed Control Systems which are considered for Froth Flotation Process Control. Systems from different manufacturers have slightly different detailed capabilities, but all have the main characteristics (a) to (f).

5.2.2 Comparison Table

Following is a table comparing some of the features of Distributed Control Systems as marketed by several manufacturers.

TABLE 5.2.2 - Page 1 of 3

MODEL AND MANUFACTURER	PROCESS SYSTEMS MICON	BAILEY NETWORK 90	ROSEMOUNT SYSTEM 3	MOORE MYCRO	FISHER & PORTER MICRO DCI	RATING ON THIS POINT
FEATURE						
CONTROLLER PACKAGING	15 Analog In 8 Analog Out 16 Discrete In 8 Discrete Out	NCOM 03 4 Analog inputs 2 Analog outputs 3 Discrete inputs 4 discrete outputs NMFC 01 252 Analog in 126 Analog out 189 DI 252 DO	16 Analog in/out (14 in, 4 out or 8 in 8 out or any other combination). Contact controllers are separate devices. Additional components make these controllers work.	Multiloop Controller 64 Analog in 32 Analog out 400 discrete. This takes physical form of one vertical cabinet.	Single Loop, each controller with its own indication and side panel configuration or controllers without indication and configuration. Can be rack mounted.	MICON superior MOORE, BAILEY, ROSEMOUNT equal F & P - single loop
LOCAL CONTROLLER CONFIGURATION AND INDICATION	Excellent. Side panel configuration and front panel indication and loop control. Can be ordered blind, and/or without configuration panel.	Configuration by buying Configuration Module. Indication by buying Digital Control Station, one for each loop where local indication/oper. is desired.	Indication by buying individual control stations for each loop needing indication. Local configuration method not shown.	Indication on CRT (in cabinet or portable). Configuration from CRT and an extra keyboard.	A rack mount version would have blind controllers, one for each loop chamelon if req'd, one supervisor, one programming panel.	MICON better F & P good MOORE next if MYCROterm is included in cabinet. ROSEMOUNT, BAILEY, equal.
KEYBOARD OR KEYBOARDS	One special purpose keyboard for all functions. Coffee proof. Special keys to access displays and manipulate control loops. Configuration and graphics generation also from this keyboard.	Special purpose keyboard for operation and configuration. Second plug-in keyboard for graphics generation. Keys to access displays and operate controllers.	Special purpose, not known if one keyboard does all functions.	For 2. Special purpose control keyboard, separate configure keyboard. Graphics generation assisted by digitizer and configuration keyboard.	One keyboard for process control a separate keyboard for configure.	MICON (1 only) BAILEY (2) ROSEMOUNT (with universal console) MOORE, ROSEMOUNT (with Mini Console) P & P, not sealed surface.

TABLE 5.2.2 - Page 2 of 3

MODEL AND MANUFACTURER	PROCESS SYSTEMS MICON	BAILEY NETWORK 90	ROSEMOUNT SYSTEM 3	MOORE MYCRO	FISHER & PORTER MICRO DCI	RATING ON THIS POINT
OPERATOR INTERFACE CHOICES	One choice only. Does all functions.	One choice. Engineering work station may be an alternate.	1. Mini Console interface. 2. Command Console interface. 3. Universal Console interface.	1. MYCRO term built-in, portable or console. 2. MYCRO basic CRT station.	Often used without CRT; Supervisor can be linked to color CRT and keyboard.	Not rated.
HOST COMPUTER INTERFACE PLC INTERFACE	PLC interface. Bulletin MDC200 11S. Computer interface 9600 baud - see Pg.85 MDC800 book. Allows access to and change of all points. Software required.	CIU computer interface unit. Software available for HP1000, Fortran level subroutines. ASCII or Binary form of transmission. PLC link also available.	Computer interface available fall of '85.	ICI-3 special device intended to provide access to all data of MYCRO system.	Available from the Supervisor at RS232 Serial various speeds. Programming required.	BAILEY (software developed) MICON, ROSEMOUNT, MOORE, F & P
CALCULATION CAPABILITY FUNCTIONS	70 functions including 10 math functions. Uses function blocks exclusively for easy programming.	MFC can do 1000 lines of BASIC for user defined functions plus 60 math functions. BASIC programming requires external terminals and external disc storage.	32 math operations. 25 other functions; also user defined functions can be written and interconnected.	27 programmed functions (algorithms). The calculator function (#18) can do any math or decisions required.	3 preprogrammed functions. User programming of other functions. Special programming language F-TRAN. Not as convenient to program.	BAILEY COM 03 but programming is awkward to to use full capability. ROSEMOUNT, MICON, MOORE, F & P
DISPLAYS ON CRT AT OPERATOR INTERFACE	Color. Real time data. Can operate from custom graphics. LOOP, MICON, GROUP, BULK GROUP, ALARM SUMMARY, TREND, INPUT with TREND, ANNUNCIATOR, FUNCTION VALUE.	Color. Real time data. Can operate from custom graphics. INPUT, LOOP, GROUP, AREA, ALARM, SYSTEM STATUS, PCU STATUS, OIU STATUS, TUNING TRENDING.	For 1 and 2. Mono Real time. GROUP, ANALOG FACE PLATE, CONTACT FACE PLATE, TREND, ALARM, CONF, STATUS. NO CUSTOM For 3. Color Many but release date is 1985.	For 2. Color Real time data. Operate from custom graphics. OVERVIEW, GROUP, GRAPHIC, POINT DTL., TREND is option.	Preformatted displays are Summary Display Group Display Point Display	BAILEY, MICON, MOORE, ROSEMOUNT

TABLE 5.2.2 - Page 3 of 3

MODEL AND MANUFACTURER	PROCESS SYSTEMS MICON	BAILEY NETWORK 90	ROSEMOUNT SYSTEM 3	MOORE MYCRO	FISHER & PORTER MICRO DCI	RATING ON THIS POINT
EXPANDABILITY	Add new MICON for each 8 loops. Keep new systems each on own MICON.	New COM for each 8 loops. New systems plug into first rack if it is big enough. One MPC would do present and future.	New systems plug into same rack 8 loops/unit.	One unit is quite large (32 Analog O) and first unit may do all future systems also.	Can be expanded, large enough for all pilot plant loops.	Little to choose. The appearance of one new MICON for each new system is a plus. For froth flotation MICON is most compact - 1 cabinet.
SPACE	Most compact installation.	One cabinet plus interface.	One cabinet plus interface.	One cabinet plus interface.	Can be all in one cabinet.	MICON, P & P, others equal.
COST WITH SIMILAR CAPABILITIES	35,684 1,376 1,238 2,591 320 1,754 18,818 8,089 15,550 7,110 $92,530	109,628 -7,269 MPC HP1000 -7,860 software $94,499	5,675 835 2,500 10,500 47,700 5,000 325 8,500 2,500 30,650 $114,185	45,500 9,560 38,220 5,720 1,050 10,005 3,900 $113,955	Not similar	MICON AND BAILEY are close. MICON preferred because of packaging. BAILEY preferred because of HP 1000 software.

5.2.3 Selection of Distributed Control System

(a) Unanswered Questions

There are some questions which should be thought out and answered before a purchase is made. These questions are about overall Pilot Plant Control System architecture.

(i) Specially what is the Pilot Plant Computer (HP 1000) supposed to provide

- an operator interface in the control room?
- archival storage?
- process mathematical modeling during process operation?

(ii) What form is desired for the operator interface for each of the future plant section control systems

- a screen and keyboard for each?

(iii) Where should digital I/O go to? All to PC? Scattered to various places?

(iv) Where should analog I/O go to? Scattered? Centralized?

(b) Our Recommendations

We recommend the MICON from Powell Systems Inc. (purchased through Cantech Controls).

The major reason for this recommendation is the arrangement of 8 loops of control in a package with integral loop display, loop operation and loop configuration capability. In other words the major reason is the Micon P 200 Controller. This packaging gives an appearance of independence, and an actual independence of sets of loops that matches best with the development plans of the Coal Research Lab. Those development plans are to develop each plant section control system at a separate time over a period of several years.

The purchase made for the froth flotation control system should include 2-MICON P 200 controllers, and a MICON MDC 200 operator interface. This operator interface will be used for the froth flotation control system and all future control systems. Our concept also includes:

(i) all analog input/output to Micon System;

(ii) all digital input/output to PLC 2/30 and linking of the PLC to MICON system.

(iii) HP 1000 Pilot Plant Computer remains outside the control room. It is linked to only 2 devices, the PLC 2/30 and the MICON MDC 200. From these two devices the Pilot Plant Computer can get all information about the pilot plant.

Some of the other reasons for recommending MICON are:

i) local P 200 indication and configuration is compact and preserves the year by year, plant section by plant section plans of CRL;

ii) first system for froth flotation can be arranged all in one vertical cabinet; one additional vertical cabinet should hold enough P 200's and terminations for all future sections of the plant;

iii) one special purpose keyboard does all functions - operate, configure, draw custom graphics, no other keyboard or template is required;

CONFIGURATION CONCEPT

MICON®'s pre-programmed configuration concept provides a library of over 70 functions which are available for each loop whether they are used initially or not. Most of these functions emulate conventional hardware devices such as PID controllers, ratio stations, adders/subtractors, multipliers/dividers, dynamic lead/lag compensators, limiters, etc. Some funtions such as adaptive PID parameters, constraint polynominal, control strategy transfer, look-up table, etc., extend well into areas which were traditionally reserved for large computers.

The functions (software modules) are selected by their number and are automatically linked ("softwired") by the microprocessor. The "softwiring" builds the selected functions into control loops.

The ability to insert or delete control functions through keyboard entries allows the user to implement control strategies as fast as they can be drawn on flow diagrams. *No computer language or experience is needed to configure MICON®*

MICON® P-200 CONTROL FUNCTIONS

INPUT CHARACTERIZATION

Analog Inputs
01 Analog Input Conversion
02 X-MTR Alarm Output
03 Fall-Back Alarm Output
04 Totalize Input
05 T/C-RTD Input Conversion

Discrete Inputs
07 Normal Contact Status
08 Status Alarm Output

LOOP CONFIGURATION

Link Functions
10 Load (specified signal)
11 Char. Analog Input
12 Temp. Comp. (Gas Meas.)
13 Press. Comp. (Gas Meas.)
14 Input Signal Switch
15 Char. Discrete Input

PID Functions
20 PID Basic Controller
21 PID Ratio
22 PID Auto-Ratio
23 PID Auto-Bias
24 PID Cascade
25 PID Gap
26 Adaptive PID Parameters
27 Keyboard PID Parameters
28 Manual Station
29 External Output Tracking

Math Functions
30 Multiply
31 Divide
32 Summation (Bias)
33 Difference
34 Square Root
35 Square

Math Functions-cont.
36 Absolute Value
37 Logarithm
38 Exponential
39 Polynomial

Limit Functions
40 Low Select
41 High Select
42 Low Limit
43 High Limit
45 Constraint
46 Transfer on Discrete
47 Transfer on Analog

Dynamic Functions
50 Lead Lag
51 Dead Time
52 Velocity Limit
53 Totalize

Output Functions
54 Uncond. Analog Output
55 Analog Output (Valve)
56 Digital Output (Valve)
57 Uncond. Discrete Output
58 Digital Valve C_v

Batch Functions
60 Transfer on Signal Value
61 Time-based Signal Transfer
62 Transfer on Discrete Status
63 Time-based Discr. Transfer
64 Uncond. Signal Transfer
65 Mode-based Signal Transfer
66 Mode-based Discrete Status

Logic Functions
70 And
71 Or
72 Invert
73 Latch
74 Timer (discrete)
75 Discrete Output
76 Virtual Discrete Access
77 Counter

Alarm Outputs
80 Signal Alarm Output
81 Dev. Alarm Output
82 PV Alarm Output
83 Rate Alarm Output

Misc. Functions
84 Loop Mode Select
85 Value Display
86 Mode Select Interlock
87 Mode Selection
88 Oscillation Monitor
89 Look-up Table

CONTROLLER TEST OUTPUT
91 Self-Test Alarm Output
92 Comm. Alarm Output

STORE FUNCTIONS
96 Signal Scaling & Store
97 Signal Scaling & Trend

SPECIAL-USE FNC
00 Terminator
99 Filler (NO-OP)

MICON® P-200 OPERATING DATA AND TUNING FUNCTIONS

Operating Data

Transmitter Range	Hi-Lo
Process Scale	Hi-Lo
Deviation Indication (Bargraph)	Hi-Lo
Deviation Alarm Setting	Hi-Lo
Transmitter Input Alarm Setting	Hi-Lo
Process Value Alarm Setting	Hi-Lo
Output Limiting	Hi-Lo
Safe Value (Fall-back) Limits	Hi-Lo

Safe Value (Fall-back value)
Set-point Ramp Limit
Digital Filter
Percent Input Calibration Readout
Loop Scan Time
Pass Word (Entry Code)

Adaptive Tuning

P Gain
I Rep/min
D Rate min
Man. Reset
Adapt. Process
Adapt. Deviation
Adapt. Output
Adapt. Contact
Output Slu (Ramp)
Gain Limit

iv) the price is competitive;

(v) available functions will do everything desired. Complex mathematical modeling is left to HP 1000.

5.2.4 Capabilities of the Distributed Control System

The distributed control system proposed (and most competing systems) can be configured to accomplish very complicated control strategies if necessary. Configuration is accomplished by using function blocks, and a list of function blocks available gives some idea of the capabilities. Remember too that these functions can be linked together - the results of one step are available for use by other steps. The following list is from MICON P 200 data which is somewhat dated; current version has these functions and more.

Any strategy that can be configured on the MICON should be, and certainly all the items shown by the P & I Drawing 02 can be done. The configuration by function blocks concept is ideally suited to a pilot plant because of the ease with which changes can be made. Control strategy changes can be made from the MICON P 200 side panel, or from the MDC 200 keyboard, by a process person. A programmer is not required.

5.3 Alternate Architecture, Alternate Control System

One control system was investigated which is much different than the systems compared on the comparison spread sheet. This is the Safe 8000 Basic Language I/O System by Control Microsystems.

The cost of this system is much less than the cost of say the MICON system. The capabilities are also much less. A Safe 8000 with enough I/O for froth flotation and with a keyboard and terminal would cost about $30,000.

5.0 CONTROLLERS AND OPERATOR INTERFACE

One Safe 8000 could probably accommodate all the pilot plant control requirements. Capacity is 128 analog I/O. 2048 digital I/O, 64 PID controllers. If all the pilot plant requirements were done by one Safe 8000 there would not be a distributed control system because all loops would be run by the one controller.

The Safe 8000 has these features:

- Accepts analog and digital I/O in various types of cards.
- Generates analog and digital output (power supply for these is from outside).
- Communicates via two RS232 ports. One is often used for a keyboard and screen monitor. The other is often used to communicate with another computer.
- Has 64 PID controllers which execute in the background; i.e. they continue to run even if the main program is stopped.
- Has an extended BASIC interpreter. Although much of this BASIC is recognizable as a quite complete version, there are also many special commands applicable to process control.
- 34K of RAM is available for the users programs (1 year power off battery back-up).
- Usually programming is done by the user to accomplish his desired control strategy, but this programming is accomplished using regular BASIC commands plus the process control BASIC commands.
- No canned programs for displays or alarms or other things, but these are possible via the users program.

- Certain commands make interface with, (exchange of data with) a host computer very easy. Three lines of program in the Safe 8000 can allow the host computer to access any variable or change any variable in the Safe 8000 program, all while the Safe 8000 program continues to run.

- The Safe 8000 is built from scratch in Canada, in Montreal.

Because of the low cost it may be possible to have several Safe 8000's, one for each section of the pilot plant. (Froth Flotation, Jig, Cyclones, etc.). This would then mean one screen and keyboard for each section, or at least one screen and keyboard that could be moved to each section. Such an arrangement is not necessarily wrong, it may be desirable to have a separate screen for each process section. It is much different than our proposed system, and our proposed architecture.

In summary this alternate system provides

- much less cost,
- no pre-programmed displays,
- no pre-programmed configuration of loops,
- more flexibility because it is not pre-programmed,
- easy programming, but programming is required,
- easy to use interface to HP 1000.

6.0 PROGRAMS

6.1 Mass Balance Program

A program to calculate mass balances between flotation feed, flotation tailings and flotation product was written. A program listing is included in the Appendix. Magnetic tape transcripts are available but can only be used with an EPSON HX 20 computer. Features of this program are:

Feed Calculations

Accepts input regarding the feed characteristics:

- flow rate (l/min)
- density of feed (Specific Gravity Units)
- density of the carrier (water, probably 1.00)
- ash content of feed.

Using a 10 point graph of ash to solids specific gravity, which can be changed for a specific type of coal, the program looks up the ash value on the graph and determines the appropriate solids specific gravity. This function is the same as f(8) and f(9) as shown on the P & ID.

Using this value for solids specific gravity, calculations are made of all the feed characteristics

- mass flow solids (kg/min)
- mass flow liquid (kg/min)
- volume flow solids (l/min)
- volume flow liquid (l/min)

Option

At this point one can choose two major routes in program execution. The first route requires entry of some values about the flotation tailings. Using these values the characteristics of the flotation product are calculated.

6.0 PROGRAMS

The second route requires input of values of a desired product. In order for the product to be as desired, and using the feed determined previously, the required characteristics of the tailings are calculated and displayed. In a real situation making adjustments to approach the required tailings specifications as closely as possible must make the product as close as possible to the desired spec and recovery.

In general this program provides a quick way to look at the mass and flow balances associated with the flotation process. The formulas used are the same as those stated on Drawing 02. The control system will do the mass balance calculations on a continuous basis.

Program Listing and sample run are in the Appendix.

6.2 Flotation Slurry Program

This program calculates the slurry characteristics and prints them in a tabular form. The resulting table is a convenient reference to relate the following properties to each other:

- specific gravity of carrier,
- specific gravity of solids,
- volume flow of feed,
- specific gravity of slurry,
- volume flow of solids,
- mass flow of solids,
- volume flow of carrier,
- mass flow of carrier,
- percent solids by volume.

The program can be easily modified to produce a table of the above characteristics that will show the expected ranges in the feed or in the tailings for a specific run of coal.

Program Listing and sample run are in the Appendix.

6.0 PROGRAMS

6.3 Simulation Programs Available From the University of Utah

Coal froth flotation process simulation programs have been written and used by the University of Utah Metallurgy Department. These programs are described in Reference 8, Phase I Report.

Dr. Herbst, head of the Metallurgy Department, University of Utah was contacted and stated that these programs can be licensed to be used by others. Dr. Herbst has promised to advise the cost and a more complete description of the programs.

This information will be provided to the Coal Research Lab as soon as it is received.

7.0 COST ESTIMATE

7.1 Basis of the Cost Estimate

7.1.1 Date and Escalation

The cost estimate is in December 1984 Canadian dollars. No allowance has been made for escalation.

7.1.2 Contingency

A 5% contingency was added to the total cost.

7.1.3 Cost of Ash Analyzers

The ash analyzers, obtained from the UK National Coal Board through Associated Mining Consultants Ltd., are a major cost item. Their price could vary because of:

- changes in exchange rate between Canadian dollar and Pound Sterling. Price is based on 1 Pound Sterling = Canadian $1.70.
- changes in requirements by EMR to designed prototype machine,
- extent of field commissioning assistance required,
- reduction if two machines are ordered at the same time.

The price quoted for the ash analyzers is anticipated to have an accuracy of ±10% or 4% of total cost.

7.1.4 Total Estimated Cost - Accuracy Statement

The total estimated cost is $528,000 including a 5% contingency. This estimate should be accurate to ±10%.

7.0 COST ESTIMATE

7.1.5 Comment about Scope

The estimate represents a certain scope of control system - as described by the accompanying drawings and report. It is possible by changing the scope to spend more. By changing the scope (simpler control system) it is also possible to spend much less, perhaps half of this total amount.

7.1.6 One Cost Estimate Summary Sheet and ten detail sheets follow.

the cambrian group

COST ESTIMATE SUMMARY

CLIENT Canmet Coal Research Lab
PROPOSAL NO. 1
LOCATION Devon Alberta
PROJECT NO. B3333
DESCRIPTION Development of a Coal Froth Flotation Control System
DATE Feb 8, 1985
BY RAH
REV. NO. 0
REV. DATE Feb 8, 1985

ACCT.	DESCRIPTION	CRAFT HOURS	LABOUR	MATERIAL	OTHER	TOTAL
	Instruments & Transmitters	230	8 050	29 800		37 850
	Control Valves	68	2 380	11 900		14 280
	Hand Valves Fittings	68	2 380	3 500		5 880
	" " " /Pipe	76	2 660	3 830		6 490
	Process Equipment	130	4 550	24 000		28 550
	Ash Analyzers	—	48 400	155 600		204 000
	[illegible]	—		94 000		94 000
	[illegible] Installation	—	9 760			9 760
	Conduit + Wire	531	18 585	8 515		27 100
	HOURS	1 103				
	DIRECT FIELD COST		96 765	331 145		427 910
H	FIELD EXPENSE	none included				
K	CONSTRUCTION SUPPLIES	included at 5% of labour				4 838
M	START-UP	allowance of $10,000				10 000
S	TEMPORARY FACILITIES	not required				
T	DEMOLITION	not required				
V	CRAFT BENEFITS	included in labor rate				
W	CONSTRUCTION TOOLS	no allowance				
	INDIRECT FIELD COST					14 838
	TOTAL FIELD COST					442 748
J	TOTAL OFFICE COST	Engineering See detail sheet				28 200
YO1	OVERHEAD	included above				
	TOTAL FIELD & OFFICE COST			SUB TOTAL 1		470 948
	PROPOSAL COST	not applicable				—
	ESCALATION	none allowed				—
	CONTINGENCY	5% allowance				23 547
				~~SUB TOTAL 2~~		—
YO2	CONSTRUCTION FEE	none - construction by own forces				—
				~~SUB TOTAL 3~~		
Q	SALES TAX & DUTIES	10% FST on material (majority will be at 10%)				33 115
R	OVERTIME PREMIUM	none				—
		Added to round final number				390
	ESTIMATED TOTAL COST			TOTAL		528 000

C122-3-72

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 1

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB /85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Measuring Instruments and Transmitters

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1	1	FE 10 + FT 10	Magnetic Flow Meter						5000	32	35	1120	6120
2	1	FE 120 + FT 120	Magnetic Flo						5000	32	35	1120	6120
3	1	AE 1 + AT 1	pH Analyzer						2300	32	35	1120	3420
4	1	FE 20 + FT 20	Turbine Flow Meter						2300	32	35	1120	3420
5	3	FE 81, FE 82, FE 83	Orifice Plate			included	below						
6	3	FT 81, FT 82, FT 83	DP transmitters			3 x	1600	→	4800	32	35	1120	5920
7	6	FI 84 thru FI 89	Rotameters			6 x 800			4800	8	35	280	5080
8	2	LT 11 + LT 12	Level Transmitter			2 @	1300		2600	16	35	560	3160
9	1	LT 40	Level Transmitter + bubbler system						2800	30	35	1050	3850
10	1	PI 90	Pressure Indicator						200	8	35	280	480
11	3	JT 71, JT 73, JT 75	Power taken from speed controllers						0	8	35	280	280
12													
	TOTAL H.P.		TOTALS ➡			LBS.			MATERIAL 29,800	HOURS 230		LABOUR 8050	TOTAL 37,850

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 2

CLIENT CSL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Control Valves & Regulators

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1	1	FV 10		$782					800	8	35	280	1080
2	3	FVF1 FVF2, FVF3		$1566 each					5000	8	35	280	5280
3	2	LV 11 + LV 12	need transducer [illegible]							8	35	280	280
4	1	DV-30		$1566					1600	8	35	280	1880
5	1	PCV-80		$594					600	8	35	280	880
6													
7	7	I/P transducers		$545 ea					3900	28	35	980	4880
8													
9													
10													
11													
12													
TOTAL H.P.			TOTALS ➔			LBS.			MATERIAL 11900	HOURS 68		LABOUR 2380	TOTAL 14,280

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

AC-110-10-76

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 3

CLIENT CFL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Hand Valves / Fittings / Pipe

	A QUANTITY	B COMPONENT	C MATERIAL UNIT COST AND UNITS	D MATERIAL COST AT SOURCE OF SUPPLY	E F.O.B.	F TOTAL WEIGHT	G FREIGHT	H MISC.	J MATERIAL COST ON SITE	K LABOUR HOURS	L RATE	M LABOUR COST	N INSTALLED COST
1	6	FV84 thru FV89	Air hand valves				@ 50		$300	4	35	140	440
2	2	3 inch ball valves	plastic		(76(2)[illegible]		@ 400		$800	8	35	280	1080
3	2	4 inch ball valves	plastic		(102(4)	020)	@ 700		$1400	8	35	280	1680
4	2	3 inch tee	plastic	76(3)001									
5	1	4 inch tee	plastic	102(4)020									
6	4	2 inch elbows	50(2)025						$500	24	35	840	1340
7	2	3 inch elbows											
8	2	4 inch elbows											
9	100'	2" PVC											
10	50'	3" PVC							$500	24	35	840	1340
11	50'	4" PVC											
12													
	TOTAL H.P.		TOTALS ➔			LBS.			MATERIAL 3500	HOURS 68		LABOUR 2380	TOTAL 5880

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 4

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Hand Valves / Fittings / Pipe cont'd

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1	5	4" 150# flanges	plastic	@ 100					$500	4	35	140	640
2	11	3" 150# flanges	plastic	@ 80					$880	4	35	140	1020
3	9	2" 150# flanges	plastic	@ 50					$450	4	35	140	590
4													
5	1	Lot Air Piping - steel, welded							$2000	64	35	2240	4240
6													
7													
8													
9													
10													
11													
12													
TOTAL H.P. ______			TOTALS ➧			LBS.			MATERIAL 3830	HOURS 76		LABOUR 2660	TOTAL 6490

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

AC-110-10-76

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 5

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

New Process Equipment

- purchase and instal

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1	3	Speed Controllers for Impeller Drives				3*3000			$9000	60	35	2100	$11,100
2													
3	1	Sala Pump and Tank							$8000	50	35	1750	$9750
4													
5	1	Reagents Tanks and Pump							$7000	20	35	700	$7700
6													
7													
8													
9													
10													
11													
12													
TOTAL H.P.		TOTALS ➡				LBS.			MATERIAL 24000	HOURS 130		LABOUR 4550	TOTAL 28,550

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

AC-110-10-76

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 6

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Ash Analyzers

- purchase and install

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1													
2		Ash Monitor		74,800					74800				74,800
3		Shipping Insurance							3,000				3,000
4		Commissioning										11,000	11,000
5		Predelivery visit										5,500	5,500
6		Instalation - electrical wiring, piping										7,700	7,700
7													
8													
9		Total for each unit											102,000
10													× 2
11													
12													
TOTAL H.P.		TOTALS ➡				LBS.			MATERIAL × 2 77800	HOURS		LABOUR × 2 24 200	TOTAL 204,000

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 7

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Distributed Control System

Purchase Price

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	~~[illegible]~~	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR ~~COST~~	INSTALLED COST
1	2	MICON P200 Controllers		17,842 each	x	2 =	35684		→ add	freight		$500	
2	2	Analog Termination Panel		688 each	x	2 =	1376		add	duty	–	0	
3	2	Discrete Termination Panel		619 each	x	2 =	1238		add	FST		0	
4	1	Power Supply		2591			2591		add	PST		0	
5	1	Solid State Relay Interface	495	+ 320 +	160 = 9	75	975		add	exchange rate			
6	2	Controller Slide Tray + Cables		877 x 2	=		1754		variance	(price based on			
7		SUB TOTAL					43618		1.32	Can = 1.00 US)		0	
8	1	COLOR CRT + KEYBOARD		18818			18818			APPROX	TOTAL		$94,000
9	1	HARD DISK UNIT		8089			8089						
10	1	MICON COMMUNICATION	UNIT	15550			15550						
11	1	CUSTOM CABINET		7110			7110						
12		SUB TOTAL					49567						
	TOTAL H.P.		TOTALS ➡			LBS.	93185		MATERIAL	HOURS		LABOUR	TOTAL

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

AC-110-10-76

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 8

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

· Distributed Control System Installation and Configuration

Installation is typically moving the panel into place, connecting to 110V power, and terminating field devices. Allow 8 man-days. Configuration is included in the purchase price. Based on a very complete documentation [illegible] to be configured. Time [illegible] 3 weeks (15 mandays).

· Running wires and connecting to instruments is included under each instrument.

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1	1	Installation								64	40		2560
2													
3	1	[illegible] configuration	[illegible]	[illegible]						120	60		7200
4													
5													
6													
7													
8													
9													
10													
11													
12													
TOTAL H.P.		TOTALS ➡				LBS.			MATERIAL	HOURS		LABOUR	TOTAL 9760

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

AC-110-10-76

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 9

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY PAH DATE FEB /85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

. Electrical Conduit and Wire

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1	12m	480V-3Ø 3 runs							315	12	35	420	720
2													
3	92m	110V-1Ø 6 runs							2000	92	35	3220	5220
4													
5	13m	24V DC 1 run							200	13	35	455	655
6													
7	414m	Instrument Connection + Control Valves - 21 runs							6000	414	35	14,490	20,490
8													
9													
10													
11													
12													
	TOTAL H.P.		TOTALS ➡			LBS.			MATERIAL 8515	HOURS 531		LABOUR 18585	TOTAL 27100

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

AC-110-10-76

the cambrian group

COST ESTIMATE

TYPE: PROPOSAL - PRELIMINARY - ESTIMATE TO COMPLETE - DEFINITIVE

APPLICABLE ACCOUNT A B C D E F G K L N P Q S T

SHEET NO. 10

CLIENT CRL LOCATION DEVON PROJECT NO. B3333 BY RAH DATE FEB/85

DESCRIPTION DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

Engineering - A detailed level of engineering has been completed, however some additional engineering is required to implement the designed system. This work to start after money approval is obtained.

	A	B	C	D	E	F	G	H	J	K	L	M	N
	QUANTITY	COMPONENT	MATERIAL UNIT COST AND UNITS	MATERIAL COST AT SOURCE OF SUPPLY	F.O.B.	TOTAL WEIGHT	FREIGHT	MISC.	MATERIAL COST ON SITE	LABOUR HOURS	RATE	LABOUR COST	INSTALLED COST
1		Obtain detailed quotations								40			
2		Evaluate quotations								30			
3		Issue purchase orders								40			
4		Detailed interconnection drawings (showing terminations)								120			
5		Inspect installation 1. Piping 2. Electrical								40			
6		DCS configuration								80			
7		Testing & calibration of instruments								40			
8		Commissioning								80			
9										—			
10										470	60	28200	28,200
11													
12													

TOTAL H.P. ______ TOTALS ➡	LBS.	MATERIAL	HOURS	LABOUR	TOTAL
				28200	28200

DATA PROCESSING

ACCOUNT NUMBER	DESCRIPTION	WEIGHT (LBS.)	HOURS	LABOUR	MATERIAL	OTHER	TOTAL

7.0 COST ESTIMATE

7.2 Phased Expenditure

7.2.1 General

The froth flotation control system can be purchased and installed in phases, one portion of the instrumentation and distributed control system at a time. Four possible phases of development are outlined below, and costs are given on Cost Estimate Summary Sheets numbered 2,3,4, and 5.

7.2.2 Phase I Development

These instruments would be included in the Phase I development; refer to Drawing 02:

FE 20, FT 20, FI 20
DY 30 (I/P), DY 30 (Low Select)
LT 40, LIC 40A, LIC 40B
FE 10, FT 10, FIC 10, FY 10, SC 10, FSL 10
DT 30 (existing), DIC 30
FIY 1, FFIC 60, FFIC 61, FY 60, FY 61

The distributed control system for Phase I development would be one only MICON P 200 mounted in a cabinet designed to allow future addition of a second P 200 and an operator interface system. At this phase there would be no screen or keyboard. Configuration of the P 200 would be from the side panel, and indication and operation would be from the front panel. There would be four analog outputs required for DV 30, SC 10, FFIC 60, FFIC 61, and indication only for FI 20, LIC 40A, LIC 40B. These seven values could use seven of the eight available displays on the P 200.

This development phase would accomplish regulation of the feed to flotation, and feed forward control of reagent addition based on mass flow of solids.

The estimated cost for this phase is $149,000.

7.2.3 Phase II Development

These instruments would be added in the Phase II development:

AE 1, AT 1, AI 1 (pH Indication)
FE 120, FT 120, FI 120 and new Sala Pump
Tailings Ash Analyzer DT 130, AT 130
NY 9, FIY 3, FIY 4, FIY 6
LT 11, LIC 11, LY 11, LT 12, LIC 12, LY 12

For this phase, the distributed control system would be expanded by adding an operator interface with color screen, keyboard, hard disc drive, communicator. Two additional analog outputs are required; therefore, one P 200 would still be sufficient. There are more analog inputs, making a total for Phase I and II of 10 analog inputs. 15 are available with one P 200.

This development phase would provide a tailings ash analyzer, and measurements of tailings SGU, tailings ash and tailings flow. Product recovery can be calculated, but not grade. This phase provides the operator interface for the distributed control system, and also, therefore, the ability to communicate with the HP 1000 computer. This phase provides pH indication and ties the flotation cell level control into the DCS.

The estimated cost for this phase is $231,000.

7.2.4 Phase III Development

These instruments would be added in the Phase III development:

Feed Ash Analyzer DT 110, AT 110, DI 110, DI 30, NY 30,
NY 8, FIY 2, FIY 5.

Phase III adds two analog inputs and requires four additional displays. Although it may not be absolutely necessary, a second MICON P 200 is added in Phase III. It will probably be required because of the additional calculation steps. Phase III development provides a feed ash analyzer and therefore the ability to control reagents based on mass flow of coal (rather than mass flow of solids). The product grade can now be calculated.

The estimated cost for this phase is $170,000.

7.2.5 Phase IV Development

These instruments would be added in Phase IV development:

FI 84, FI 85, FI 86, FI 87, FI 88, FI 89
FV 84, FV 85, FV 86, FV 87, FV 88, FV 89
FE 81, FT 81, FIC 81, FY 81, FV 81
FE 82, FT 82, FIC 82, FY 82, FV 82
FE 83, FT 83, FIC 83, FY 83, FV 83
NY 81, NY 82, NY 83
JT 71, NIC 92, SI 92, SC 92
JT 73, NIC 94, SI 94, SC 94
JT 75, NIC 96, SI 96, SC 96

This development requires six additional analog inputs and six analog outputs. This will, with feed ash analyzer, fill the capacity of the second MICON P 200 controller. No new distributed control system hardware will be required.

Phase IV development provides (impeller speed) to (air) coupling. This phase is the phase in which air measurement and control is implemented. It could be argued that air control is more important than feed ash measurement. Phase IV could be implemented before Phase III. The second MICON P 200 controller would be required for Phase III or Phase IV, whichever is done first.

The estimated cost for this phase is $66,000.

7.2.6 Total Cost to Develop by Phases

The total estimated cost for all four phases is $616,000. This is $88,000 more than the estimated cost to proceed in one step because of the additional repetitive input required for four projects, compared to the input required for one project.

the cambrian group

PHASE I

COST ESTIMATE SUMMARY

CLIENT Canmet Coal Research Lab
PROPOSAL NO. 2
LOCATION Devon, Alberta
PROJECT NO. B3333
DESCRIPTION Development of a Coal Froth Flotation Control System
DATE March 5, 1985
BY RAH
REV. NO. 0
REV. DATE March 5, 1985

ACCT.	DESCRIPTION	CRAFT HOURS	LABOUR	MATERIAL	OTHER	TOTAL
	Instruments + Transmitters					13 390
	Control Valves					7 840
	Hand Valves Fittings					2 420
	" " " Pipe					2 250
	Process Equipment					7 700
	Ash Analyzers					0
	Distributed Control System					32 886
	DCS Installation					9 760
	Conduit + Wire					15 875
	DIRECT FIELD COST					92 121
H	FIELD EXPENSE	none included				
K	CONSTRUCTION SUPPLIES	included at 2% of DFC				1 842
M	START-UP	allowance of 8,000				8 000
S	TEMPORARY FACILITIES	not required				
T	DEMOLITION	not required				
V	CRAFT BENEFITS	included in labor rate				
W	CONSTRUCTION TOOLS	no allowance				
	INDIRECT FIELD COST					9 842
	TOTAL FIELD COST					101 963
J	TOTAL OFFICE COST	Engineering				28 200
YO1	OVERHEAD	included above				
	TOTAL FIELD & OFFICE COST	SUB TOTAL 1				
	PROPOSAL COST	not applicable				
	ESCALATION	none allowed				
	CONTINGENCY	5% allowance				5 098
		SUB TOTAL 2				135 261
YO2	CONSTRUCTION FEE	none - by own forces				
		SUB TOTAL 3				
Q	SALES TAX & DUTIES	10%				13 526
R	OVERTIME PREMIUM	none				
		Adder to round final estimate.				213
	ESTIMATED TOTAL COST	TOTAL				149 000

the cambrian group

PHASE II

COST ESTIMATE SUMMARY

CLIENT Canmet Coal Research Lab
PROPOSAL NO. 3
LOCATION Devon, Alberta
PROJECT NO. B3333
DESCRIPTION Development of a Coal Froth Flotation Control System.
DATE March 5, 1985
BY RAH
REV. NO. 0 REV. DATE March 5, 1985

ACCT.	DESCRIPTION	CRAFT HOURS	LABOUR	MATERIAL	OTHER	TOTAL
	Instruments + Transmitters					9 280
	Control Valves					280
	Hand Valves Fittings					1 680
	" " " Pipe.					0
	Process Equipment					9 750
	Ash Analyzers					102 000
	Distributed Control System					42 457
	DCS Installation					9 760
	Conduit + Wire					5 000
	DIRECT FIELD COST					180 207
H	FIELD EXPENSE	none included				
K	CONSTRUCTION SUPPLIES	included at 2% of DFC				3 604
M	START-UP	allowance of 8,000				8 000
S	TEMPORARY FACILITIES	not required				
T	DEMOLITION	not required				
V	CRAFT BENEFITS	included in labor rate				
W	CONSTRUCTION TOOLS	no allowance				
	INDIRECT FIELD COST					11 604
	TOTAL FIELD COST					191 811
J	TOTAL OFFICE COST	Engineering				8 000
YO1	OVERHEAD	included above				
	TOTAL FIELD & OFFICE COST			SUB TOTAL 1		
	PROPOSAL COST	not applicable				
	ESCALATION	none allowed				
	CONTINGENCY	5% allowance				9 590
				SUB TOTAL 2		209 401
YO2	CONSTRUCTION FEE	none - by own forces				
				SUB TOTAL 3		
Q	SALES TAX & DUTIES	10%				20 940
R	OVERTIME PREMIUM	none				
		Adder to round final numeric.				659
	ESTIMATED TOTAL COST			TOTAL		231 000

the cambrian group

COST ESTIMATE SUMMARY

PHASE III

CLIENT Canmet Coal Research Lab
PROPOSAL NO. 4
LOCATION Devon, Alberta
PROJECT NO. B3333
DESCRIPTION Development of a Coal Froth Flotation Control System
DATE March 5, 1985
BY RAH
REV. NO. 0
REV. DATE March 5, 1985

ACCT.	DESCRIPTION	CRAFT HOURS	LABOUR	MATERIAL	OTHER	TOTAL
	Instruments + Transmitters					3 420
	Control Valves					0
	Hand Valves Fittings					0
	" " " Pipe.					0
	Process Equipment					0
	Ash Analyzers					102 000
	Distributed Control System					17 842
	DCS Instalation					5 000
	Conduit + Wire					3 000
	DIRECT FIELD COST					131 262
H	FIELD EXFENSE	none included				
K	CONSTRUCTION SUPPLIES	included at 2% of DFC				2 625
M	START-UP	allowance of 8 000				8 000
S	TEMPORARY FACILITIES	not required				
T	DEMOLITION	not required				
V	CRAFT BENEFITS	included in labor rate				
W	CONSTRUCTION TOOLS	no allowance				
	INDIRECT FIELD COST					10 625
	TOTAL FIELD COST					141 887
J	TOTAL OFFICE COST	Engineering				5 000
YO1	OVERHEAD	included above				
	TOTAL FIELD & OFFICE COST			SUB TOTAL 1		
	PROPOSAL COST	not applicable				
	ESCALATION	none allowed				
	CONTINGENCY	5% allowance				7 094
				SUB TOTAL 2		153 981
YO2	CONSTRUCTION FEE	none - by own forces.				
				SUB TOTAL 3		
Q	SALES TAX & DUTIES	10%				15 398
R	OVERTIME PREMIUM	none				
	Adder to round final value.					621
	ESTIMATED TOTAL COST			TOTAL		170 000

the cambrian group

COST ESTIMATE SUMMARY

PHASE IV

CLIENT Canmet Coal Research Lab
PROPOSAL NO. 5
LOCATION Devon, Alberta
PROJECT NO. B3333
DESCRIPTION Development of a Coal Froth Flotation Control System
DATE March 5, 1985
BY RAH
REV. NO. 0
REV. DATE March 5, 1985

ACCT.	DESCRIPTION	CRAFT HOURS	LABOUR	MATERIAL	OTHER	TOTAL
	Instruments & Transmitters					11 760
	Control Valves					6 160
	Hand Valves Fittings					1 780
	" " " Pipe					4 240
	Process Equipment					11 100
	Ash Analyzers					0
	Distributed Control System					0
	DCS Instalation					5 000
	Conduit & Wire					3 210
	DIRECT FIELD COST					43 250
H	FIELD EXPENSE	none included				
K	CONSTRUCTION SUPPLIES	included at 2% of DFC				865
M	START-UP	allowance of 8,000				8 000
S	TEMPORARY FACILITIES	not required				
T	DEMOLITION	not required				
V	CRAFT BENEFITS	included in labor rate				
W	CONSTRUCTION TOOLS	no allowance				
	INDIRECT FIELD COST					8 865
	TOTAL FIELD COST					52 115
J	TOTAL OFFICE COST	Engineering				5 000
YO1	OVERHEAD	included above				
	TOTAL FIELD & OFFICE COST			SUB TOTAL 1		57 115
	PROPOSAL COST	not applicable				
	ESCALATION	none allowed				
	CONTINGENCY	5% allowance				2 856
				SUB TOTAL 2		
YO2	CONSTRUCTION FEE	none - by own forces				
				SUB TOTAL 3		59 971
Q	SALES TAX & DUTIES	10%				5 997
R	OVERTIME PREMIUM	none				
	Adder to round final estimate					32
	ESTIMATED TOTAL COST			TOTAL		66 000

APPENDIX INDEX

1. Specification for Distributed Control System
2. Reagent Pumps Data
3. Sala Pump Data
4. Speed Controllers Data
5. Torque Sensor Data
6. MICON Budget Quote
7. Business Cards
8. Ash Analyzer
9. Basis for Phase III Design
10. Originally Planned System Architecture
11. Program Listings and Sample Results
12. Full Size Drawing Prints

Volume

2

the cambrian engineering group limited

the cambrian engineering group limited

PROFESSIONAL ENGINEER ALBERTA
R. ALAN HOAR

R A Hoar
March 1985

DEVELOPMENT OF A COAL FROTH FLOTATION CONTROL SYSTEM

PHASE III SYSTEM DESIGN

VOLUME 2 - APPENDIX

D.S.S. Contract Serial No. 0SQ83-00287

D.S.S. File Number 03SQ23440-3-9048

Project No. B3333

February, 1985

APPENDIX INDEX

1. Specification for Distributed Control System
2. Reagent Pumps Data
3. Sala Pump Data
4. Speed Controllers Data
5. Torque Sensor Data
6. MICON Budget Quote
7. Business Cards
8. Ash Analyzer
9. Basis for Phase III Design
10. Originally Planned System Architecture
11. Program Listings and Sample Results
12. Full Size Drawing Prints

APPENDIX 1

Specification for Distributed Control System

SPECIFICATION FOR DISTRIBUTED CONTROL SYSTEM FOR FROTH FLOTATION CONTROL

PRE-BIDDING DRAFT VERSION

TABLE OF CONTENTS

PAGE

1.0 SCOPE OF WORK AND CONTRACTOR REQUIREMENTS
(This section not included at this time)

2.0 CONTRACTOR'S QUALIFICATIONS AND INFORMATION REQUIRED
(This section not included at this time)

3.0 GENERAL REQUIREMENTS OF FLOTATION CONTROL SYSTEM 1

4.0 CONTROL CENTRE 7

5.0 CENTRAL COMPUTER INTERFACE 14

6.0 PROCESS CONTROLLERS AND INPUT TERMINATION 15

7.0 ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS 18

8.0 I/O SUMMARY 22

3.0 GENERAL REQUIREMENTS OF FLOTATION CONTROL SYSTEM

3.1 I/O Count

3.1.1 All hardware, software, wiring terminations, and other materials, necessary to support the quantity and type of input/output points and control loops, including spares, shall be provided as specified herein, and included in the Contract Price.

3.2 Services

3.2.1 All services necessary for the complete and proper implementation of the Flotation Control System as specified herein shall be provided and included in the Price. Such services shall include, but not be limited to, the following:

- Configuration Assistance;
- meeting with Owner and Vendor, including design meetings and progress review meetings;
- system integration and testing;
- pre-shipment staging and factory testing;
- shipping to site;
- pre-commissioning checks of the Flotation Control System;
- training;
- documentation and drawings;
- guarantees and warranty repairs or replacement.

3.3 Displays and Logs

3.3.1 All point descriptors, display formats, log formats, and other customized portions of the Work shall be approved by the Owner before implementation of such functions begins.

3.4 Pre-Shipment Staging and Testing

The components of the Flotation Control System shall be staged, connected together, and tested as a functioning system before shipment to the site for installation. This test shall be referred to as the Pre-Shipment Performance Test. The Test shall include, but not be limited to, comprehensive testing of the following:

- all functions specified or provided;
- certain possible abnormal situations;
- each individual I/O point and control loop, using simulated end devices;
- each calculation performed by the Work;
- device communications timing and loading;
- spare parts.

3.5 Documentation and Drawings

3.5.1 Five copies and one reproducible of the following Vendor documents shall be provided:

a) Operator's manual;

b) engineering or user's manual describing how the Work may be modified in the future, and how the Work is presently configured.

c) maintenance manual, describing how Owner's electronics maintenance personnel can perform preventative maintenance, troubleshooting, repairs, additions, deletions, and modifications;

The above manuals shall be provided for each component of the Control System, including Operator's consoles, process control units, communications devices, peripheral devices, etc.

3.5.2 Five copies and one reproducible of the following drawings shall be provided:

a) Typical Configuration Drawing - This will illustrate the controllers, the operator interface, the communications, showing interconnecting cables.

b) Operator's Console Layout - This will be a scale drawing of the operator's console, showing front, side, and top perspectives. Locations of the various components (i.e. video display, keyboard, communications panels) will be shown. Dimensions will be shown. Electrical connections and wiring will be illustrated and described.

c) Cabinet Layouts - If an additional cabinet is required, cabinet layout drawings shall be provided. The drawings shall be to scale, and shall illustrate all of the components in each cabinet and their electrical interconnections, and cabinet mechanical mounting specifications.

d) Termination Schedule - This drawing shall list and/or illustrate all terminations indicating terminal/connector numbers, tag names, voltages, currents, polarities, and grounding/shielding requirements. This shall be done for terminal strips and for any cable provided by the Vendor.

3.5.3 The above documentation and drawings shall be well organized and easily understood, and shall contain comprehensive tables of contents and alphabetical indexes. Topics for each of the hardware components shall include, but not be limited to, the following:

- Operator's procedures;
- start-up procedures;
- procedure for periodic adjustments by operators and maintenance personnel;
- technical description and theory of operation;
- installation procedure;
- maintenance procedure;
- schematic and logic diagrams;
- list and descriptions of all system error messages;
- drawings as specified above;
- component interconnection procedures;
- parts lists;
- troubleshooting procedure;

3.6 Training

3.6.1 Vendor training shall be provided on site after installation, but before start-up.

3.6.2 The proposed course shall be described in terms of:

- duration;
- schedule;
- prerequisites.

3.6.3 The cost for training shall be included in the Price but itemized separately.

3.7 Shipping

3.7.1 Delivery of the Flotation Control System equipment shall be made by the Vendor to the site.

3.7.2 The Vendor shall provide suitable packing and crating such that the equipment will be loaded, shipped, off-loaded, and delivered to its final location(s) of installation safely and without damage.

3.7.3 The cost of packing and shipping shall be included in the Contract Price.

3.7.4 The Vendor shall choose the carrier, and the vehicle shall be suitable for transporting electronic equipment. The carrier shall use a dedicated van, with no transfers to other vehicles en route. The Vendor shall be present to supervise all on-loadings and off-loadings.

3.8 Pre-Commissioning Checks

3.8.1 After being connected to the Plant's end devices on site, the Flotation Control System shall undergo pre-commissioning checks. These checks shall be similar in intent and format to the Pre-Shipment Performance Test and shall be conducted before trials with the flotation machines operating.

3.9 Electrical Approvals

3.9.1 Where CSA approval is not available, Alberta Electrical Protection Branch approval will be acceptable with the permission of the Owner.

3.10 Guarantees

3.10.1 All Flotation Control System materials, components, software, and equipment shall be guaranteed to be free of defects in materials and workmanship.

3.10.2 All guarantees shall be described in terms of:

- duration of guarantee after successful completion of the performance tests;
- costs specifically included in and excluded from the guarantee, such as:
  - travel time and expenses,
  - point of origin,
  - shipping costs,
  - items repaired/replaced on site,
  - items repaired/replaced in factory,
  - labor on site,
  - labor in factory or maintenance facility,
  - parts;

- location(s) of maintenance facilities for repairing the faulty component;
- guaranteed turn-around time for factory or maintenance facility repair;
- guaranteed response time for repairs required to be performed on site.

3.10.3 If a part or component cannot be repaired to its original physical and operational condition to the Owner's satisfaction, the Contractor or its Vendor shall replace the component with a new component.

3.10.4 The Owner shall have the right to make modifications, additions, or deletions to any portion of the Work during the Guarantee Period. Should it be demonstrated that any such modifications have caused the Work to become faulty, and should the Contractor or its Vendor be required to repair such fault, then the Owner shall reimburse the Contractor or its Vendor for: all repair and travel time according to the submitted Rate Schedule; all repair or replacement components according to unit prices provided in the Contract Documents or standard list prices of the Vendor if unit prices are not given; and all travel, accommodation and living expenses of necessary personnel at cost plus 10 percent. This shall in no way otherwise affect the one year Guarantee Period.

3.10.5 The Contractor or its Vendor shall provide during the Guarantee Period at no additional charge any new software or hardware release notes, version changes or other modification descriptions resulting from upgrades to the hardware or software.

3.10.6 Should any engineering, design or component changes be required in order to perform a repair, the resulting repaired component shall meet all Contract requirements, including, but not limited to, any requirements for rugged construction, power consumption, wiring patches, printed circuit board construction and temperature operating range. The Contractor or its Vendor shall correspondingly correct all copies of all documentation, drawings, schematics, and parts lists, within ten days of having repaired the fault.

3.10.7 All repairs shall be done in a manner which will provide the greatest convenience and the least disruption to the Owner.

3.10.8 If a failure occurs in the Work during the Guarantee Period, the Guarantee Period shall be extended by the length of time during which the failure existed. A failure shall be defined as any function normally available to the operator or user that is not performing as described in the Contract Documents. Loss of a computer peripheral device or any redundant component shall not be considered a failure if the identical function or data is otherwise immediately recoverable. The first loss of any component for which the Contractor recommended that a spare component be purchased shall not be considered a failure. If a faulty component or components could be made functional by replacement of spare components as recommended by the Contractor and set forth in the Form of Tender, and providing that the quantity of spare components, as recommended, exceeds the current quantity of failed components, then a failure shall not be deemed to have existed. A failure shall commence when the Owner notifies the Contractor of the failure. The Owner shall document the failure in writing to the Contractor. A failure shall terminate when the function or data is available.

3.10.9 In the event that any repair work must, as determined by the Owner, be carried out sooner than the time limits specified in this Clause, to prevent serious damage, injury, or loss of life, the Owner may perform or cause to be performed the necessary repair and shall notify the Contractor. For work required and determined by the Owner to be in circumstances which will not cause serious damage, injury, or loss of life, the Contractor or its Vendor shall perform such repairs within the time limits specified in item 3.10.2 above. In the event that such work is not performed within the specified time limits, the Owner may perform or cause to be performed such work. All repair costs resulting from work performed or caused to be performed by the Owner shall be borne by the Contractor.

3.11 Maintenance, Service and Spares

3.11.1 Recommended Spare Parts List for the Flotation Control System shall be provided.

3.11.2 The Contractor shall describe any maintenance contracts which are available to the Owner from the Vendor and shall also state how the contract(s) differs from the services provided by the Vendor in the Guarantee.

3.11.3 The Contractor shall recommend any test equipment necessary for the proper maintenance of the Work.

4.0 CONTROL CENTER

4.1 Hardware Requirements

4.1.1 The Control Center shall include at least the following equipment:

a) One 19 inch color CRT complete with:

- non-glare screen,
- one operator's keyboard (see 4.1.2),
- lockable (by code or key) access to Operate, Tune and Configure modes of operation.

b) Hard Copy Device with capability to:

- log alarms and operator changes,
- generate alarm summary,
- generate system log (automatic and manual),
- document configuration,
- copy screen (with adequate resolution).

c) Bulk Storage System to be used for:

- configuration storage and loading,
- displays at operator interface.

d) Console as described:

- to house or support all equipment located at the Operator Station,
- provide lockable side hinged doors (front and rear) to access internal equipment.

4.1.2 The Operator's keyboard requirements are:

- a special purpose design oriented to Process Control functions,
- clearly labelled single function keys,
- digital entry keys,
- slewing keys to ramp setpoints and outputs,
- alarm silence and alarm acknowledge keys.

4.1.3 Combination of Operator Interface and Process Control

Combination of all devices into one cabinet would be very desirable because of limited control room size. Suggested configuration would be CRT in center; mass storage, communictions and other parts associated with the operator interface located below the CRT; control modules and field terminations located above the CRT. Keyboard located on a slide out (preferable) or fixed shelf at desk height.

4.2 Operational Requirements

4.2.1 The following capabilities are required of the Operator Station:

- Configure all equipment supplied as part of the Control System.
- Operate the Control System.
- Tune the Control System.
- Reconfigure the Control System during operation.
- Provide Operator access to all data available through the Control System.
- Visual annunciation of alarms and output for audible annunciation.
- Reject invalid entries without any adverse effects on the Control System

4.3 CRT Displays

4.3.1 The CRT must have the following capabilities:

- Provide User Configurable Custom Graphical Displays (flowsheet style).
- Plant Overview display.
- Group displays.
- Detail displays.
- Alarm displays.
- Discrete Status displays.
- Trend displays.

4.3.2 The Control System Graphical Display capabilities shall include at least the following:

- user configurable,
- process flowsheet style displays,
- libraries of standard symbols which can be accessed and altered for building displays,
- library into which user generated symbols can be placed for recall and reuse,
- mixed graphic and numeric display.
- animation of displays (responsive to process changes),
- color changes of symbols and status descriptors in response to alarms, status changes, etc.

4.3.3 The Plant Overview Display (Group Overview Display)shall:

- indicate process variable deviation from setpoint with per point, user selectable, percentage of range at full scale,
- arrange the points on the Overview Display in the order of appearance in the Group Displays,
- indicate the names and numbers of the Group Displays,
- indicate the points in alarm by color change (flashing until acknowledged).

4.3.4 The Group Displays shall allow mixtures of Analog loop " faceplate like" displays, and Discrete Status displays, each capable of providing at least the following information and functions:

a) Analog displays:

- loop tag number,
- loop descriptor,
- transmitter range (zero and full scale values in Engineering Units),
- Engineering Units descriptor,
- controller mode (when applicable),
- alarm status (with descriptors),
- both analog and digital indication of setpoint, process variable and output,
- ability to change controller mode, setpoint, ratio, bias, and output (where applicable),
- ability to acknowledge alarms within the group displayed.

b) Discrete Status displays:

- point tag number,
- point descriptor,
- "off state" descriptor,
- "on state" descriptor (different color than off state),
- ability to change status when the point is a discrete output,
- colors of state descriptors shall be different from those of alarm state descriptors.

4.3.5 The Detail Displays shall provide all of the following capabilities in addition to those of the Group Displays:

a) Analog Displays:

- loop tuning constants (where applicable),
- ratio and bias (where applicable),
- alarm settings,
- configuration data,
- ability to change loop tuning constants, alarm settings, ratio, bias, etc. when "keylock" enabled,
- cross-reference data when the loop is a part of a cascade loop or any other interactive arrangement that may be configured.

b) Input Displays:

- transmitter ranges,
- transmitter safe values,
- input trending, adjustable time base

c) Alarm Displays:

- indication and control of assignment of the alarm point to alarm logging and annunciation functions.

d) Discrete Status Displays:

- status of discretes.

4.3.6 The Trend Display shall contain the following information:

- one, two or three Trend Displays at one time,
- loop tag number,
- at least 60 ponts of data displayed per Trend,
- averaged values,
- vertical axis calibration (Engineering Units),
- horizontal axis calibration (time of event).

4.3.7 The following features shall be available for Operator use on the Trend Display:

- timebase compression and expansion.

4.3.8 For each of the User configured descriptors including:

- tag numbers,
- engineering units,
- range values,
- point descriptors,
- alarm point,
- on, off, normal and alarm state descriptors,

the following information is required:

- maximum number of characters,
- maximum and minimum numerical values (if applicable),
- does this descriptor come from a library or can a unique "word or message" be assigned to every entry in the System?
- if from a different library, describe how many different libraries exist, how many unique entries can be placed per library and whether any stringing of entries is required to assemble descriptors.

4.3.9 A means of locating displays via directly keying in a tag number should be provided.

4.4 Configuring

4.4.1 Configuration mode must be restriced by a keylock to Authorized Engineering Personnel only.

4.4.2 All equipment necessary to perform the following functions must be included:

- initial configuration generation,
- storage of configuration (including sufficient Bulk Storage Medium),
- copying System Configuration onto Bulk Storage Medium,
- loading configuration from Bulk Storage Medium into the System,
- modifying configuration during System operation without interference to other devices or loops,
- instruction manuals and sufficient blank configuration forms.

4.5 Tuning

4.5.1 Tuning mode must be restricted by a "Keylock" or code to Authorized Engineering Personnel only.

4.5.2 Tuning must be performed from the Operator's Keyboard.

4.5.3 Tuning parameters must be saved on the Configuration Storage medium with transfer available via an "Upload" procedure.

4.6 Alarm Handling

4.6.1 It must be possible to assign alarm logging and annunciation functions independent of each other and on a per point basis.

4.6.2 The occurrence of any alarm within the Control System shall result in the following responses:

- a change in color (to red) of the point alarm status indicator affected in all displays in which it is found,

- flashing of the above point alarm status indicators until acknowledged,

- output for audible annunciation,

- printout of the alarms (if assigned) in order of occurrence, including the following details:

    - tag number,
    - point descriptor,
    - alarm state indicator,
    - time on,
    - time off,
    - time and date of occurrence.

4.6.3 Printouts, as described above, shall also occur when alarms are acknowledged and when they return to normal.

4.6.4 Annunciation shall not cease without acknowledgement when points return to normal.

4.6.5 Annunciation is not required when points return to normal.

4.6.6 The Alarm Silence Key shall immediately silence the audible annunciation of any alarm.

4.6.7 Acknowledgement of any alarm shall be inhibited until sufficient detail is presented on the display to identify the nature of the problem to the Operator (eg. Detail Display or Group Display including the annunciating alarm point).

4.6.8 A means of quickly and easily guiding the Operator to displays of annunciating points must be provided. This could be a list of displays with unacknowledged alarms or a key for directly accessing the appropriate displays.

4.7 Printer

4.7.1 The printer shall have the following capabilities:

- producing configuration documentation,
- logging operator activities (i.e. mode changes, data entries, alarm acknowledgements, etc.),
- logging time and date with all printouts,
- logging alarms,
- generating alarm summaries,
- generating system logs,
- copying screen (including graphic type displays).

4.7.2 The Bid shall identify any capability of generating customized format printouts if included.

4.8 Bulk Storage System

4.8.1 The Bulk Storage System shall have the following capabilities:

- transfer configuration from Bulk Storage Medium to the Control System,
- transfer configuration (including current tuning constants and alarm settings, etc.) to Bulk Storage Medium for permanent storage,

4.9 Interface to PLC

The system shall be designed to interface with Allen Bradley PLC 2/30. Status of programmable controller points shall be indicated on appropriate displays as configured. Status of certain few programmable controller points will be required to be used as a digital input to the process controller via this interface.

5.0 CENTRAL COMPUTER INTERFACE

The Computer Interface shall allow an upper-echelon (host) computer to read or alter any data in the distributed controllers either direct or via the central, CRT-based operator station.

The Computer Interface is to be a standard feature of the distributed system and shall not require any special hardware or software to be added to the system.

The interface shall use the three-wire RS-232 (CCITT V.24) voltage level hardware protocol.

5.1 Computer Enable/Disable

The Computer pushbutton(s) on the Central Operator Station and/or on the Distributed Controllers shall allow the operator to enable or disable the supervisory computer at any time.

5.2 Data Structures and Communication Protocol

The Vendor must supply, as part of the quotation, detailed information concerning transmission protocol and communication formats to and from the computer. The explanation of the data transfer structure and protocol shall include (but not be limited to) the following:

- Internal data structure defining numeric data formats and Tag structure.
- Communication message protocol specifying message structure.
- Host computer messages showing interface control, alarm reporting, dynamic data request and modification. Error codes and control configuration messages are to be included in the information.

6.0 PROCESS CONTROLLERS AND INPUT TERMINATION

6.1 Hardware Requirements

6.1.1 Sufficient floor standing Equipment Racks of a suitable design must be supplied to meet the following specifications:

- mount all equipment not located at the console (see 4.1.3),
- provide termination for all I/O wiring to the process measurement and control devices,
- I/O wiring entry at top of cabinet,
- ventilation to limit internal temperature rise to 3 degrees Celsius above Electronics Room ambient (include fans if required),
- side hinged front access doors with keylock.

6.2 I/O Requirements

6.2.1 The Process Controllers and Termination Units must have the following capabilities: (all types of inputs must be available from Vendor, although some will not be included in initial order)

- immunity to electrical noise superimposed upon signals,
- receive and transmit both Control and Non-Control (indicate only) signals,
- 4-20 mA inputs and outputs,
- 1-5 V inputs,
- isolated discrete inputs and outputs (24 VDC),
- A/D and D/A accuracies - 0.1% minimum,
- cycle time not to exceed 1 second.

6.2.2 The Bid shall supply the following specifications for the equipment proposed:

- A/D and D/A converter accuracies, resolutions, long term stability, etc.
- Common Mode Rejection Ratio

6.3 Signal Processing

6.3.1 The Process Controllers must have the following signal (PV) input processing capabilities:

- digital filtering,
- Engineering Unit conversion,
- alarm checking:
  - absolute
  - deviation
  - rate of change
- detection of out of range inputs (i.e. transmitter failure). Normal PV alarms are not acceptable for this function.
- linearization of TC and RTD signals received by the PCU and Data Acquisition Unit as 4-20 mA.

6.3.2 Any accumulated data (totalizations, etc.) shall not be lost due to any power failures.

6.4 Process Controller Functional Requirements

6.4.1 The following functional capabilities are required of the Process Controllers:

a) Manual, Auto, Remote Set Point (Cascade), Supervisory and DDC modes of operation;

b) bumpless and balanceless transfers (i.e. setpoint and process variable tracking features must be available for use with interactive configurations);

c) P, PI, PID, Ratio, Bias, Feedforward, Lead/Lag control algorithms must be available;

d) software connected interactive configurations including:

- cascade loops,
- signal selectors,
- signal transfers;

e) software executed functions for use within the Controllers including at least:

- add, subtract, multiply, divide,
- square root, exponential, log, absolute value,
- gap action, adaptive gain, anti-reset windup,
- signal selection (high, middle, low),

- signal limiters (absolute value, rate of change),
- digital filtering,
- signal comparisons,
- logical operations,
- look-up tables,
- remote (software controlled) controller mode switching.

6.4.2 The Controllers shall not be affected by invalid entries or operations at the Console.

6.4.3 The Controllers shall complete all assigned tasks at least once every second.

6.5 Controller Failure

6.5.1 The Control System shall incorporate the following features:

- minimize the extent to which any component failure can affect operation,
- ability to continue without interruption during temporary loss of communication with console.

6.6 Controller Configuration

6.6.1 Reconfiguration of individual loops and devices during operation must be possible without interference to other operating loops or controllers.

7.0 ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

7.1 Codes

All equipment supplied must be CSA approved and meet all applicable electrical codes. The equipment shall bear CSA labels. Where CSA approval is not available, Alberta Electrical Protection Branch approval will be acceptable only with the permission of the Owner.

7.2 Area Classification

The System shall be installed in a control building classified as "General Purpose" in accordance with the National Electrical Code. The system will be connected to field devices located in areas as specified on individual instrument spec. sheets.

7.3 Transient, Static and RFI Protection

The system shall be internally protected against SYSTEM ERRORS and HARDWARE DAMAGE resulting from:

a) Electrical transients on power or signal wiring (IEEE STANDARD 472-1974 shall apply).

b) Static discharge, normally present during cold dry weather, due to personnel contacting equipment, wiring or terminals which electrically form a part of the Control System or Shutdown System.

c) Connecting and disconnecting devices, removing and inserting cables during operation. (The effect of such disconnections shall be limited to the loss of use of disconnected equipment only).

7.4 AC Power

7.4.1 The Control System will be supplied with 110 VAC power.

7.4.2 The bid shall define the 110 VAC power requirements of the Control System including specifications as follows:

- number of separate circuits required,
- all locations to which power must be supplied,
- normal, maximum and inrush current levels,
- voltage tolerances,
- frequency tolerances,
- waveform distortion tolerance.

7.4.3 The effects of the Control System Operation due to the following occurrences shall be specified:

- overvoltage,
- undervoltage,
- frequency change,
- waveform distortion.

7.4.4 The bid shall specify the effects on the Control System and Shutdown System due to complete loss of 110 VAC power and any restart procedures required following reconnection of power.

7.5 DC Power

7.5.1 All DC Power required to operate the Control System internal equipment, both at the Console and Equipment Racks, shall be derived from Power Supplies supplied with the System. Power supply failures must be detected and annunciated. A quick and easy means of locating defective power supplies is required.

7.5.2 All DC Power required to excite external transmitters and drive external transducers shall be derived from Power Supplies supplied with the System.

7.5.3 The Power Supplies must be overcurrent and overvoltage protected.

7.5.4 Sufficient power supply capacity is required to allow Control System expansion to the limits of the I/O capacity of the equipment racks included in the proposal.

7.5.5 The presence of any Battery Backup Systems included in the bid must be identified along with any maintenance procedures that may be required. (Battery backup is not a requirement).

7.6 Fusing

7.6.1 All fusing necessary for the protection of the Control System, and any connected devices shall be provided as an integral part of the system. The following requirements shall be satsified:

- use only common fuse types readily available from local supplier's stock,

- provide easy access,

- quick change without disassembly, removal or de-energization of any components or circuitry,

- supply 10% spare fuses with the systems.

7.6.2 The I/O fusing arrangement shall be designed to minimize the extent to which the Control System would be affected by the opening of any fuse.

7.7 Grounding

The grounding requirements for the Control System shall be clearly defined in the bid.

7.8 Signal Levels

7.8.1 All analog I/O shall be operated at 4-20 mA.

7.8.2 All analog inputs must be capable of withstanding a full 24 VDC placed on the input terminal indefinitely, without damage to any component, including range resistors, or risk of degrading equipment operation.

7.8.3 The Control System bid price shall be based on 24 VDC discrete I/O. The bid should state the ability of the Control System to operate at other voltages (i.e. 110 VAC, 125 VDC, etc.).

7.8.4 Discrete output loads can be assumed as follows:

- maximum continuous load 12 VA per point,
- average continuous load 5.7 VA per point.

7.9 Equipment Connection

7.9.1 All interconnections between components of the System shall be via prefabricated (to length) and preterminated cables supplied with the system.

7.9.2 All plugs, receptacles and cables must be clearly, uniquely and permanently labelled.

7.9.3 All plug in cables and devices (including circuit boards) must be coded to prevent incorrect connection. A suitable locking device must also be provided to prevent accidental disconnection. Circuit boards shall be guided for insertion.

7.9.4 All field wiring must terminate only at the equipment racks on terminal strips provided for this purpose. The bid shall state the maximum wire size that may be accommodated.

7.10 Miscellaneous

7.10.1 All transmitted analog input signals shall be 4-20 mA. All analog input positions shall be provided with 250 ohm 0.1% 3 watt resistors included with the system. These resistors must be easily removable in the field for conversion to voltage inputs (i.e. not soldered in place).

7.10.2 All analog output signals shall be 4-20 mA driving external loads which are returned to the signal common of the System. It must be possible to handle loads ranging from 0 to 600 ohms.

7.10.3 Discrete inputs and outputs shall be electrically isolated from each other and from the Control System circuitry. Assume operation at 24 VDC and indicate any capability to work with 110 VAC and 125 VDC.

7.10.4 The System purchased must include documentation of all card types, model numbers, part numbers and locations within the system. The settings of all switches on circuit boards, etc., shall also be documented and described to assist maintenance personnel when card swapping, testing or calibrating.

7.10.5 Troubleshooting guides and procedures must be supplied with the system.

8.0 I/O SUMMARY

8.1 The Control System shall be capable of providing an efficient and effective means by which the operator can control the Flotation Plant. All control devices and process measurements necessary are to form a part of the control system I/O.

8.2 The hardware requirements are as follows:

a) Controller I/O

17 - 4-20 mA analog inputs
12 - 4-20 mA analog outputs
12 - Control loops are required of which
- 12 are single controller loops
- 0 are 2 control cascade loops
- 6* are arranged in complex (3 or more controllers) configurations
  (* 2 groups of three).

b) Indicators

1 - 4-20 mA input
0 - 100 ohm Platinum RTD inputs
0 - type (-) thermocouple inputs
12 - shared display indicators

c) Manual Outputs

0 - 4-20 mA outputs

d) Discrete inputs - 9
Discrete outputs - 3

APPENDIX 2

Reagent Pumps Data

the cambrian
engineering group limited

RECORD OF TELEPHONE CONVERSATION

FROM: Charles, Zazula Process Equipment (Name and Title) DATE: Dec 5/84

TO: Al Hoar (Name and Title) TIME: 10:30 am

JOB NUMBER: B3333 JOB NAME Coal Froth Flotation

RE: Metering Pumps

1. Milton Roy mRoy

   Duplex Pump

   FR-210A-37

   $4496 with 2 electric micrometer adjustments

2. Skid with 2 tanks, strainer valves all in PVC. Actuator wired to controller

   $1600 total for the skid, tanks, etc.

ZAZULA PROCESS EQUIPMENT LTD.

1526 - 10th AVENUE S.W. - CALGARY, ALBERTA T3C 0J5
TELEPHONE (403) 244-0751 TLX 038-24541

December 5, 1984

Cambrian Engineering
4815 - 78 Avenue S.W.
Calgary, Alberta
T2C 2Y9

Attention: Mr. Al Hoar

Subject: Requested Information

Dear Sir:

It was indeed a pleasure to talk with you. We have enclosed the information you requested. If anything is unclear, please call and we will do our best to help you.

Zazula Process Equipment handles Milton Roy metering pumps, Zazula water and waste-water treatment systems, Greey LIGHTNIN mixers, Dow plastic lined pipe, Busch vacuum pumps, Pumpex submersible sewage pumps, Fluorocarbon slide bearings, Liquid Dynamics pulsation dampeners, Astrometallurgical Corporation titanium pipe and fittings, and Atwood & Morrill high technology valves.

The reputations of these companies are well known and it is upon them we have built our own reputation. We offer quick reliable service and an earnest goodwill to do the best possible job for our customers.

Zazula Process Equipment Ltd. also maintains a 3500 square foot manufacturing facility in Calgary where custom fabrication is performed. The following is a list of some typical items designed and built at our shop:

- chemical feed systems (steel and stainless steel);
- pressure vessels;
- tanks, skids, structural steel as required;
- water treatment (filters, softeners, deaerators, package systems);
- ladders, platforms.

Please call us with your next related inquiry.

Yours very truly,

ZAZULA PROCESS EQUIPMENT LTD.

/kd

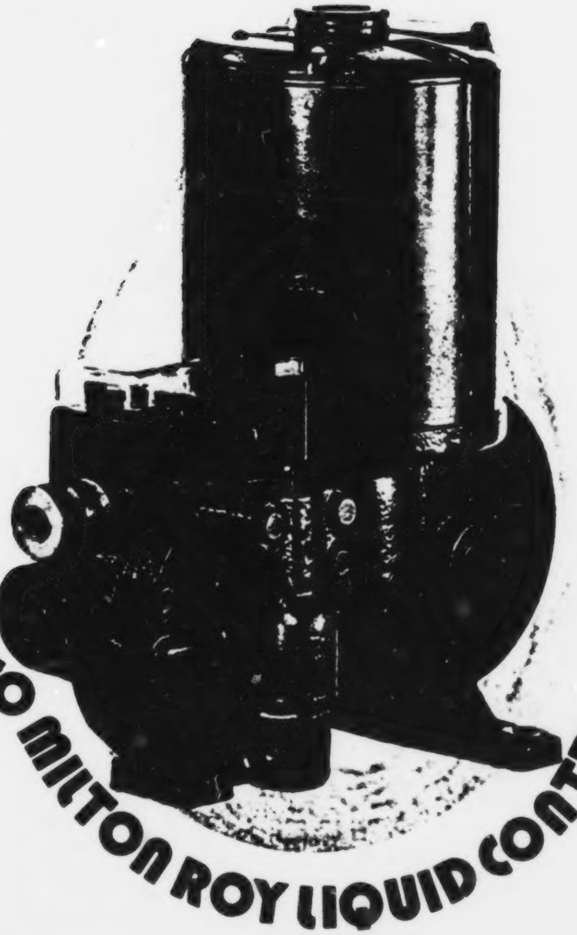
Charles Hilton

Encl.

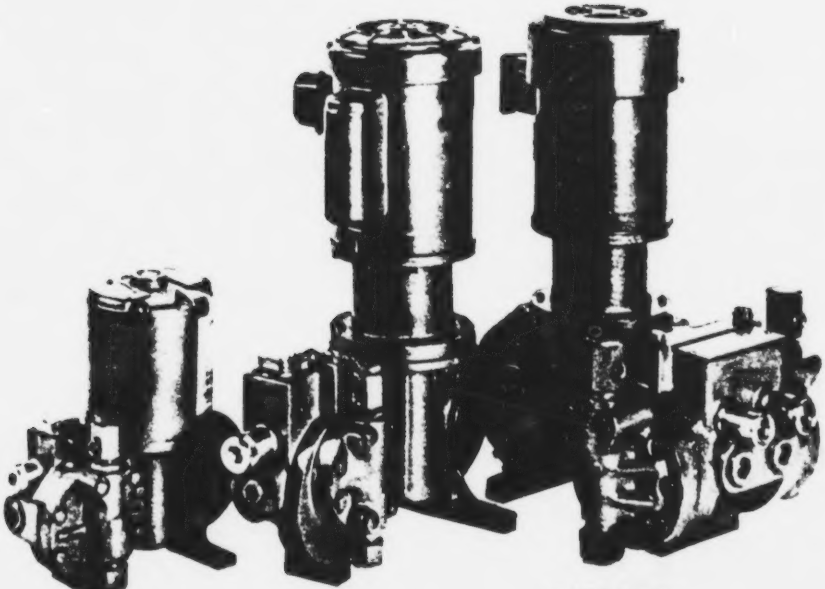
BULLETIN 15.001 C

MILTON ROY

mROY®
CONTROLLED VOLUME PUMPS



...LOOK INTO MILTON ROY LIQUID CONTROL BEFORE YOU BUY.



FRAME A FRAME B FRAME B DUPLEX

Like this
but duplex

Copyright 1978, Milton Roy Company

U.S. Patent Nos. 3149 489; 2889 946

mRoy® controlled volume pumps

FEATURES

- ☐ ± 1% repetitive accuracy.
- ☐ Capacity adjustable over full range whether the pump is operating or not.
- ☐ Motors rated for continuous duty at maximum output.
- ☐ Severe duty, chemical environment and super extra tough (SXT) motors are available — many carried in stock.
- ☐ Fully enclosed motor and drive.
- ☐ Light-weight, compact mRoy design, requires minimum amount of floor space and allows for ease of pump movement.
- ☐ All moving parts operate in oil.
- ☐ Built-in relief valve provides full pump protection.
- ☐ Finished with chemical resistant paint.
- ☐ Easily converted from manual to automatic control in field.
- ☐ Low maintenance requirements.
- ☐ Meets present O.S.H.A. standards.

In 1936 Milton Roy Company introduced the revolutionary "step-valve" controlled volume pump, giving birth to a whole new technology in the field of precise flow control instruments.

This first Milton Roy pump had the unique ability to operate at high pressures while maintaining a constant flow rate within ±1% of the capacity setting, and yet requiring very little maintenance over long periods of time. Water treatment and chemical process engineers immediately recognized the advantages of using this new pump, and the demand for the instrument soon far exceeded the supply.

Acknowledging the fact that Milton Roy's design was far superior to that of their own, competitive pump manufacturers began to imitate, and attempt to improve upon, the original Milton Roy pump. Despite these efforts, Milton Roy Company still maintains recognition as the leading designer and manufacturer of controlled volume pumps.

The economical mRoy was developed in 1962 to meet the industry's need for a low-cost, accurate, hydraulically actuated diaphragm pump that could handle a wide range of liquids. All standard mRoys readily handle liquids and light slurries having viscosities to 200 s.s.u. (40 centipoises). Many mRoys, however, are being used to handle liquids with much higher viscosities (up to 6000 s.s.u. in some cases). A Milton Roy sales representative should be consulted when selecting an mRoy to handle liquids with viscosities over 200 s.s.u. A constant flow rate is accurately maintained within ±1% of the pump capacity setting, and the durability of the precise mRoy has been proven over and over again by thousands of satisfied mRoy users. Its consistent accuracy over long periods of time prompts Milton Roy Company to tell their customers to: "Install an mRoy and forget it."

The mRoy has been applied widely to meter chemicals into boiler feed water, cooling tower water, process water, and industrial waste and sewage treatment systems. Formulation processes of such products as dyes, paints, varnishes, lacquers and pharmaceuticals rely on precise flow control of often expensive ingredients in small volumes. Here again the mRoy has proven its rugged durability and consistent accuracy.

Two sizes of the mRoy are available, Frame A or Frame B. Either size can be provided in simplex or duplex configurations, with integrally mounted totally enclosed motors, or with NEMA C-Face Flange mounted motors. For applications requiring special characteristics, a wide selection of liquid end materials will assist you in choosing a pump to specifically handle the type of liquid you wish to meter.

The mRoy Frame A is powered by a ¼ horsepower motor and has a capacity range of 0.08 to 28 gph in the simplex version and to 56 gph in the duplex configuration. The mRoy Frame B is larger and is driven by a ½ horsepower motor. Capacity ranges for the Frame B simplex are 0.4 to 106 gph and to 212 gph in the duplex. Detailed specifications and dimensions are shown on pages six and seven of this bulletin.

The mRoy is only one of a full line of controlled volume pumps and accessories manufactured by Milton Roy Company for use in industrial and laboratory processes. So no matter what the liquid or environment is, call or write the Milton Roy sales office nearest you. A company representative, expert in applying these flow control instruments, will be pleased to assist you in selecting and ordering the pumps you need to suit your particular application.

mRoy® controls

Controls are available for the mRoy to suit nearly any requirement. Control of pump output from 0 to 100% can be achieved by varying effective plunger displacement manually, electrically or pneumatically. In cases where there are special system requirements, variable speed drive motors are available to control pump output by varying stroking rate.

All three capacity adjustments allow variation of delivery over the full range of 100% capacity equally well whether the pump is operating or not. The mRoy can be depended upon to maintain a constant flow rate within ±1% of pump output at any single pump capacity setting.

MICROMETER CAPACITY ADJUSTMENT

The manually operated micrometer knob is conveniently located on the end of the mRoy housing and is easily read. Micrometer adjustment is the usual method of capacity control when the mRoy is installed in an accessible location and is being used to feed liquid at one fixed rate for long periods.

ELECTRIC CAPACITY ADJUSTMENT

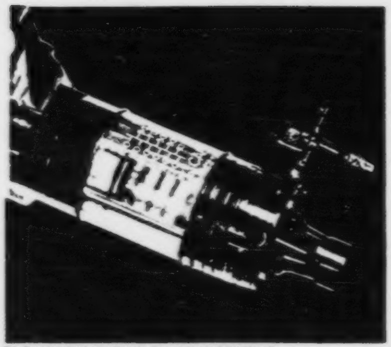
The electric capacity actuator mounts directly on the mRoy in place of the standard micrometer knob. This actuator regulates the pump's flow rate in response to an electrical signal from a remotely located control unit. Control units are available to suit a wide variety of control applications, including remote manual, or automatic control directly from process control instruments.

PNEUMATIC CAPACITY ADJUSTMENT

The pneumatic capacity actuator mounts directly on the mRoy in place of the standard micrometer knob. This actuator regulates the pump's flow rate in response to pneumatic signals from a remotely located control unit.

In addition to the standard 3-15 psi signal, actuators are available to accept other standard ranges, such as 3-27 psi, and various split ranges.

Pneumatic control units are available to suit a wide variety of applications, including remote manual, or automatic control directly from process control instruments.

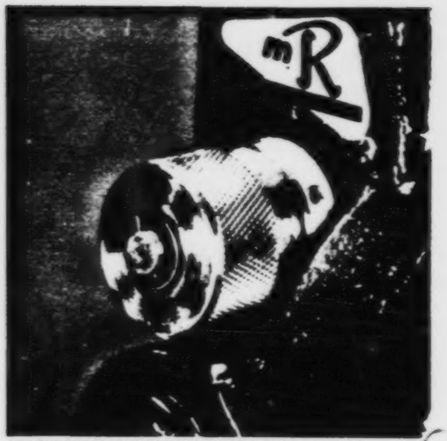


PNEUMATIC CAPACITY ADJUSTMENT

VARIABLE SPEED MOTORS

All mRoys can be provided with variable speed motors and remote control units for manual or automatic control of pump stroking speed.

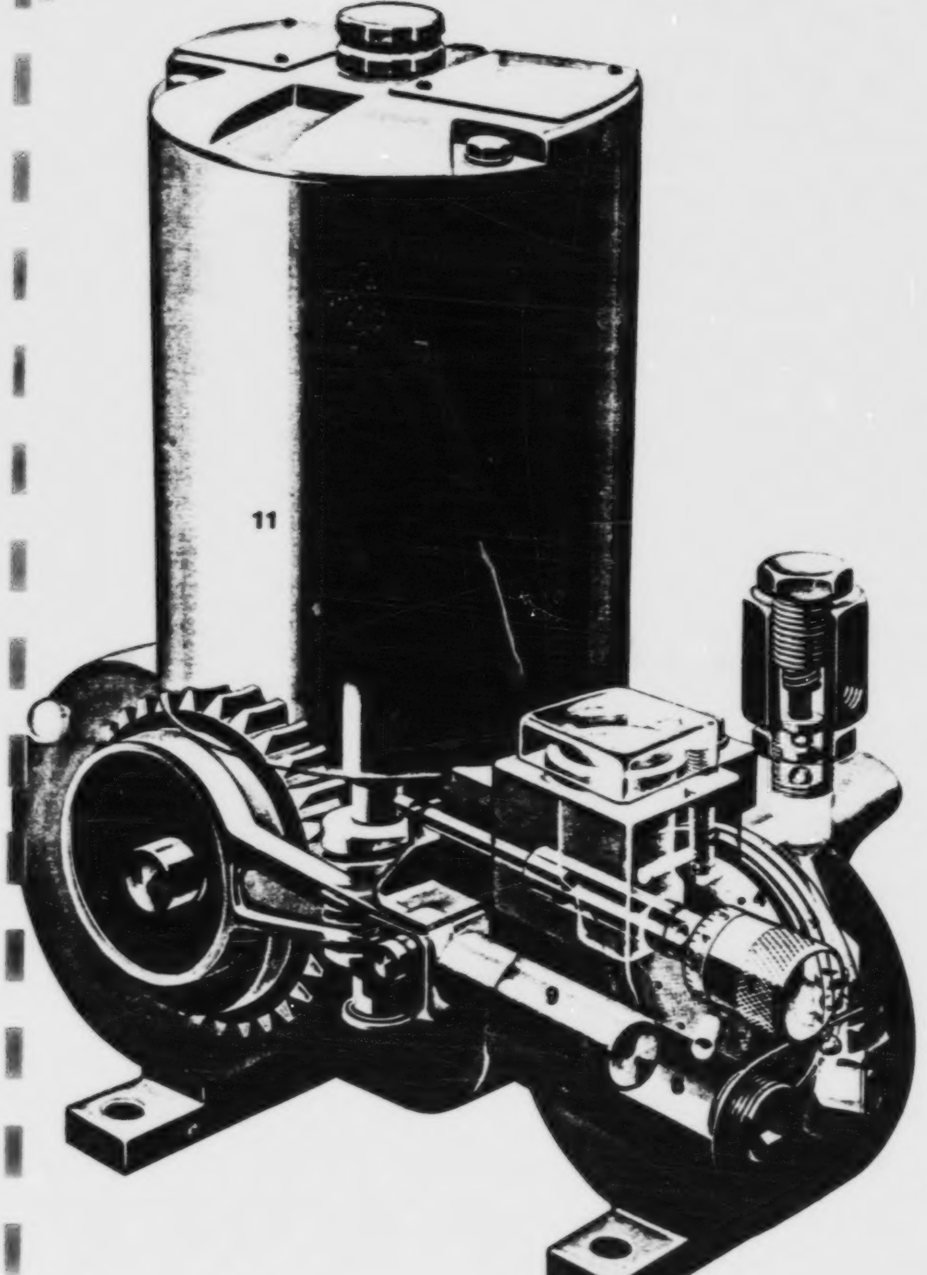
Stroke speed control is often used in proportional feed systems where the speed of a pump feeding a chemical additive into a process is controlled in fixed proportion to a varying process flow rate, and the capacity adjustment (micrometer, electric, or pneumatic) is used to set the required "dosage" rate of the additive.



MICROMETER CAPACITY ADJUSTMENT

ELECTRIC CAPACITY ADJUSTMENT

mRoy features



1. Repetitive accuracy guaranteed by automatic air venting on each pump stroke to prevent vapor accumulation.

2. Built-in relief valve prevents pump damage if discharge system is blocked during operation.

3. Dependable double ball check valves in easily replaceable cartridges for simplified maintenance.

4. Proven Teflon[1] diaphragm design is fatigue-resistant and leakproof under normal operation.

5. Diaphragm head can be remotely located for submerged tank pumping of dangerous liquids.

6. Self-compensating hydraulic system — no vacuum breakers or refill valves to adjust.

7. Positive capacity adjustment over full flow range during operation. Electric or pneumatic capacity adjustment options available for remote or process instrument control.

8. Hydraulically actuated diaphragm is not pressure loaded, acts only as separating membrane between liquids.

9. Precise plunger-bore fit with generous bearing area eliminates plunger packing, extends service life.

10. All moving parts are continuously submerged in lubricating oil to assure long, efficient pump life.

11. Compact design with self-contained totally enclosed motor[2] and drive allows installation in almost any location or environment.

---

[1] A Dupont Registered Trademark

[2] Special motors can also be provided for severe duty applications.

mRoy specifications

mROY DIAPHRAGM PUMPS, FRAME A

MAXIMUM CAPACITY GPH @ 100 PSI[5]		MAXIMUM DISCHARGE PRESSURE PSI	STROKES PER MINUTE[6]	MATERIALS OF CONSTRUCTION	MODEL NUMBERS[1,2]	
SIMPLEX	DUPLEX				SIMPLEX	DUPLEX
0.8 1.8 2.8	1.6 3.6 5.6	700 1100 1100	37 73 117	Cast Iron 316 Stainless PVC[3] Spec. (H2SO4) CA-20 SS	R110 R111 R112 R113[8] R115	R210 R211 R212 R213[8] R215
1.8 2.8	3.6 5.6	1800 1800	73 117	Cast Iron 316 Stainless	R100 R101	R200 R201
1.8 3.8 6.2 9.5	3.6 7.6 12.4 19.0	700 925 925 500	37 73 117 185[4]	Cast Iron 316 Stainless PVC[3] Spec. (H2SO4) CA-20 SS	R120 R121 R122 R123 R125	R220 R221 R222 R223 R225
11.2 18 28	22.4 36 56	350 350 200	73 117 185[4]	Cast Iron 316 Stainless PVC[3] Spec. (H2SO4) CA-20 SS	R130 R131 R132 R133 R135	R230 R231 R232 R233 R235

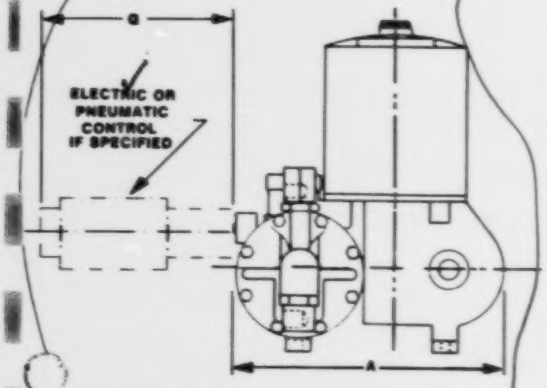
mROY DIAPHRAGM PUMPS, FRAME B

MAXIMUM CAPACITY GPH @ 100 PSI[5]		MAXIMUM DISCHARGE PRESSURE PSI[7]	STROKES PER MINUTE[6]	MATERIALS OF CONSTRUCTION	MODEL NUMBERS[1,2]	
SIMPLEX	DUPLEX				SIMPLEX	DUPLEX
4.75 7 9.5 14	9.5 14 19 28	1100 1100 1100 1100	48 72 96 144	Cast Iron 316 Stainless Spec. (H2SO4) Steel CA-20 SS	R140 R141 R143 R144 R145	R240 R241 R243 R244 R245
10 16 21 32 40	20 32 42 64 80	500 500 500 500 300	48 72 96 144 185[4]	Cast Iron 316 Stainless H. D. Polyethylene[3] Spec. (H2SO4) Steel CA-20 SS	R150 R151 R152 R153 R154 R155	R250 R251 R252 R253 R254 R255
27 42 57 85 106	54 84 114 170 212	100 100 100 100 100	48 72 96 144 185[4]	Cast Iron 316 Stainless H. D. Polyethylene[3] Spec. (H2SO4) Steel CA-20 SS	R160 R161 R162 R163 R164 R165	R260 R261 R262 R263 R264 R265

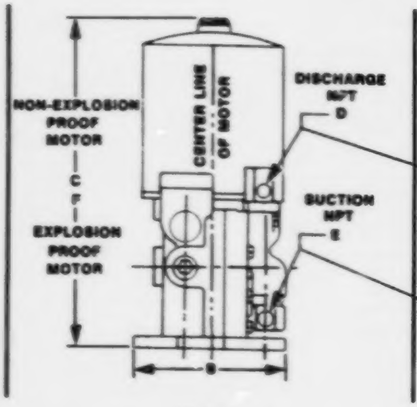
NOTES:

1. mRoys above have totally enclosed motors integrally mounted — Frame A mRoys are ¼ HP 1-60-115 volt 1725 rpm tenv; Frame B mRoys are ½ HP 3-60/50 230/460 volt 1725/1425 rpm tenv.
2. Stock motors are available in other voltages, enclosures and speeds. Consult sales representative.
3. Plastic liquid ends limited to 150 psi at 150°F.
4. 185 spm mRoys have maximum viscosity limitations. Consult sales representative.
5. The capacities shown above are for 100 psi, and will decrease approximately 1.5% for each 100 psi increase in discharge pressure. This does not reflect in any way upon repetitive accuracy.
6. When ordering add identifying suffix to indicate stroke speed desired. Example: To order a cast iron mRoy Frame A with a 0.8 GPH capacity, a discharge capacity of 700 psi operating at 37 strokes per minute specify: R110-37.
7. Higher discharge pressures are attainable through the use of a ¾ horsepower motor. Contact the nearest Milton Roy Sales Office for further information.
8. These models not available in Spec. H2SO4 in 73 and 117 strokes per minute versions.

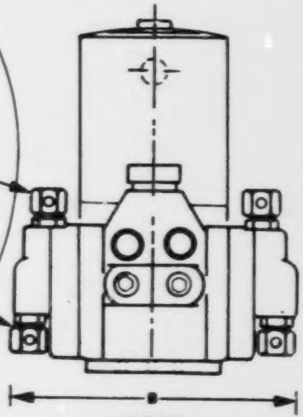
mRoy dimensions and shipping weights


G
ELECTRIC OR PNEUMATIC CONTROL IF SPECIFIED
A

SIMPLEX & DUPLEX
SIDE VIEW


NON-EXPLOSION PROOF MOTOR
C
F
EXPLOSION PROOF MOTOR
CENTER LINE OF MOTOR
DISCHARGE NPT
D
SUCTION NPT
E
B

SIMPLEX
FRONT VIEW



DUPLEX
FRONT VIEW

MODEL NUMBERS	A	B	C	D	E MET	E PLAST	F	G	SHIPPING WEIGHT
R100-R135	11 5/8	7	13 3/8	1/4-18	3/8-18	1/4-18	24	7	55
R200-R235	12 3/8	10 1/2	13 3/8	1/4-18	3/8-18	1/4-18	24	7	60
R140-R145 R240-R245	18 3/4	9 1/4	18 5/8	1/4-18 1/4-18	3/8-18 3/8-18	— —	28	7	135 190
R150-R165 R250-R265	18 3/4	13 1/4	18 5/8	3/8-18 3/8-18	1/2-14 1/2-14	1/2-14 1/2-14	28	7	135 190

Above dimensions typical for all pumps where applicable.
All dimensions are approximate.
All dimensions in inches and weights in pounds.

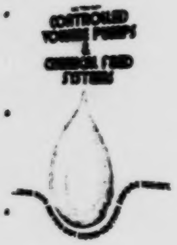
ORDERING DATA

When ordering, please specify the following:

1. Liquid to be pumped.
2. Liquid viscosity range.
3. Liquid temperature range.
4. Maximum and normal operating capacities in gallons per hour.
5. Discharge pressure, maximum and normal.
6. Suction conditions.
7. Electrical characteristics of motor, if other than standard.

need more information?

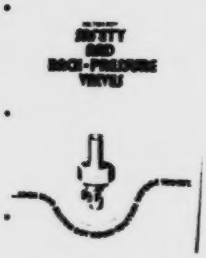
Write to Milton Roy Company, 201 Ivyland Road
Ivyland, Pennsylvania 18974 for these free publications.



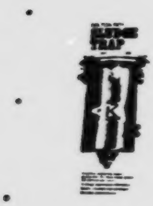
Controlled Volume Pumps and Chemical Feed Systems, general bulletin describing the Milton Roy line of controlled volume pumps and accessories. Request Bulletin 100.13

Milroyal Controlled Volume Pumps, describes the Milroyal line of controlled volume pumps. Information given on liquid ends, controls, operation, capacities, pressures and dimensions. Request Bulletin 35.001.

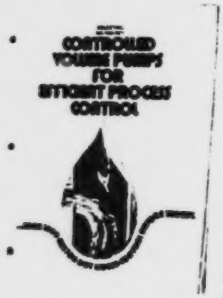
Milroyal D Controlled Volume Pump, describes features and specifications for this compact controlled volume pump. Request Bulletin 36.001.



Safety Valves and Back Pressure Valves. Bulletin gives description and specifications for Milton Roy safety and back pressure valves. Request Bulletin 55.001.



Milton Roy Sludge Trap. Bulletin describing how Milton Roy sludge trap can prevent sludge build-up when metering sulfuric acid. Request Bulletin 459.



Selecting Milton Roy Controlled Volume Pumps For Efficient Process Control, explains the principles of metering pumps. Request Bulletin 100.

MILTON ROY

INDUSTRIES LTD.

PETERBOROUGH, ONTARIO

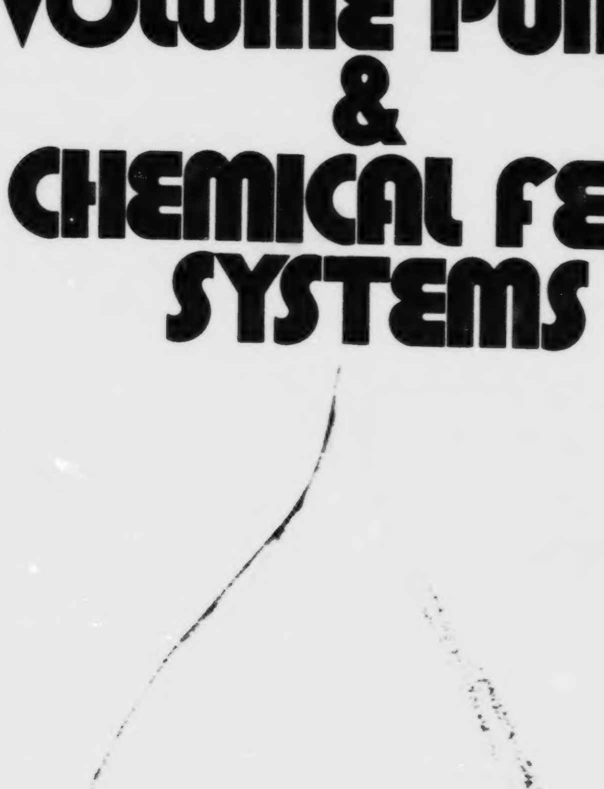
TECHNOLOGY IN FLUIDS

10M879

BULLETIN 100 13 C

MILTON ROY

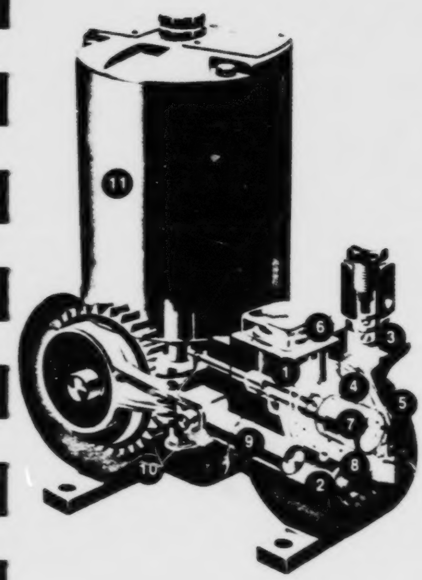
CONTROLLED VOLUME PUMPS & CHEMICAL FEED SYSTEMS



...LOOK INTO MILTON ROY LIQUID CONTROL BEFORE YOU BUY.

LOOK INTO MILTON ROY...

Controlled Volume Pumps



mROY

The economical mRoy controlled volume pump was designed to meet industry's need for a low-cost, accurate, hydraulically actuated diaphragm pump that can handle a wide range of corrosive liquids and light slurries.

When you look inside an mRoy you will find...

1. Repetitive accuracy guaranteed by automatic air venting on each pump stroke to prevent vapor accumulation.
2. Self-compensating hydraulic system—no vacuum breakers or refill valves to adjust.
3. Dependable double ball check valves in easily replaceable cartridges for simplified maintenance.
4. Proven Teflon* diaphragm design is fatigue-resistant and leak-proof under normal operation.
5. Diaphragm head can be remotely located for submerged tank pumping of dangerous liquids.
6. Built-in relief valve prevents pump damage if discharge system is blocked during operation.
7. Positive capacity adjustment over full flow range during operation. Electric or pneumatic capacity adjustment options available for remote or process instrument control.
8. Hydraulically actuated diaphragm is pressure balanced, acts only as separating membrane between liquids.
9. Precise plunger-bore fit with generous bearing area eliminates plunger packing, extends service life.
10. All moving parts are continuously submerged in lubricating oil to assure long, efficient pump life.
11. Compact design with self-contained totally enclosed motor** and drive allows installation in almost any location or environment.

These features are indicative of the quality that has made the mRoy the most preferred instrument for metering chemicals into cooling tower water, process water, and industrial waste and sewage treatment systems as well as for proportioning the often expensive ingredients that go into the formulation of products such as dyes, paints, varnishes, lacquers and pharmaceuticals.

Two sizes of the mRoy are offered, Frame A or Frame B. Either size can be provided in simplex or duplex configurations, with integrally-mounted, totally enclosed motors, or with NEMA C-Face Flange mounted motors. For applications requiring handling of corrosive liquids, a wide selection of liquid end materials is available.

All standard mRoys readily handle corrosive liquids having viscosities to 200 s.s.u. (40 centipoises). mRoys are often used to pump heavier liquids and light slurries (some have been used to pump liquids with viscosities to 6000 s.s.u. and higher). For these special applications call your nearest Milton Roy sales office for assistance.

Capacity adjustment: Manual over full flow range by micrometer dial. Available with pneumatic or electric stroke adjustment for automatic capacity control. Also adjustable by variable speed drives.

Capacity: Frame A: 0.08 to 28 gph (simplex) to 56 gph (duplex).
Frame B: 0.4 to 106 gph (simplex) to 212 gph (duplex).

Repeatable accuracy: Within ± 1%.

Discharge pressure: Frame A: To 1800 psi with standard ¼ HP motor. Frame B: To 1100 psi with standard ½ HP motor.

Dimensions: (approximate)
Frame A Simplex: 7" wide, 13½" high, 11½" deep.

Frame B Simplex: 9¼" wide, 18⅝" high, 18¾" deep.

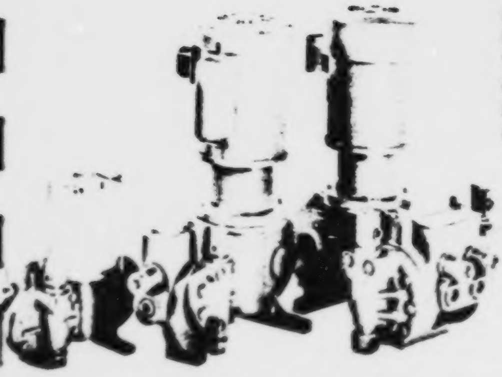
Request Bulletin 15.001 for complete details.

U.S. Patent Numbers 3149 469, 2888 946

---

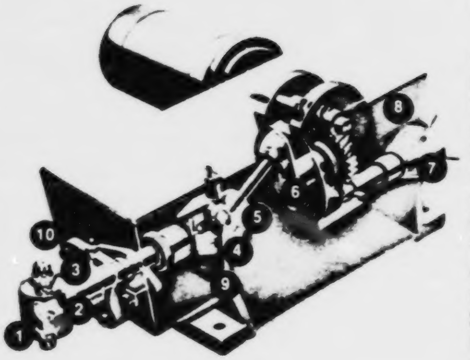
* A DuPont registered trademark

** Special motors can also be provided for severe duty applications



FRAME A FRAME B FRAME B DUPLEX

Copyright® 1974, Milton Roy Company



Milroyal

The Milroyal is designed and built with maximum precision to accurately proportion highly corrosive chemicals, solvents, viscous liquids, and slurries in adverse environments. Continuous operation at flow rates to 1,000 gph against pressures to 7,500 psi requires durability. That's why when you look into a Milroyal you find:

1. A choice of either packed plunger, conventional diaphragm, or tubular double diaphragm liquid ends.

2. Free turning, self cleaning double ball check valves help guarantee accuracy to within ±1%.

3. Internal relief valve on diaphragm models to provide positive protection against overloads.

4. Magnetic oil cleaner reduces wear of moving parts and extends oil life.

5. Pressurized lubrication at key points promotes long life under high pressure loads.

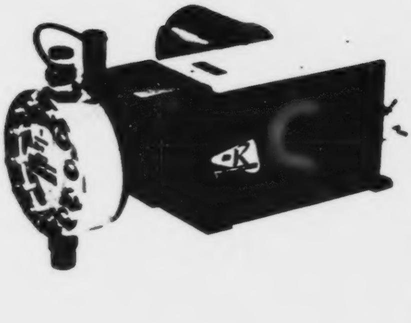
6. Patented polar crank drive generates smooth plunger action.

7. Positive micrometer adjustment possible over full flow range while operating. Electric and pneumatic capacity adjustment available for most models.

8. Totally enclosed design prevents dirt, moisture or corrosive vapors from reaching drive mechanism.

9. Separate lubricating and hydraulic chambers eliminate oil selection compromises and reduce air entrainment.

10. On diaphragm models, a patented air bleeding valve automatically removes air from hydraulic fluid to insure accuracy.



Milroyal with Diaphragm Liquid End

Designed to pump highly corrosive, toxic and other hazardous liquid chemicals precisely. Leak-proof design safely controls the flow of expensive and dangerous liquids. Displacement chamber is sealed with Teflon* diaphragm. No mechanical linkage between drive and diaphragm and no plunger packing maintenance required.

Capacity: 0.2 to 605 gph (duplex or multiplex models available).

Capacity adjustment: Manual over full flow range with micrometer dial. Available for most models with pneumatic or electrical stroke adjustment for remote or automatic control. Variable speed drives also available.

Discharge pressure: To 3,500 psi.

Accuracy: ±1%.

Dimensions: (approximate, less motor and liquid end).

Models A & B: 8" wide, 11" high, 27" deep.

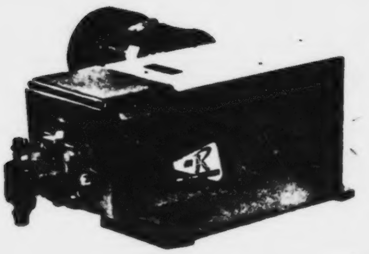
Model C: 13" wide, 18" high, 48" deep.

Construction: Cast steel, 316 stainless steel, Milroy stainless steel (similar to Carpenter 20), alloys HB and HC, a special construction for concentrated H_2SO_4, and plastics.

Ask for Technical Bulletin 35 and a quotation based on your requirements.

U.S. Patent Numbers 3, 075, 813; 2, 892, 352

*A DuPont registered trademark



Milroyal® with Packed Plunger Liquid End

Accurately controls corrosive chemicals, light solvents, high-viscosity liquids and slurries. Features straight through flow for pumping heavy slurries, while inclined passages eliminates air on each pump stroke. Has self-lubricating drive mechanism plus free-turning self-cleaning ball checks.

Capacity: 0.1 to 1,000 gph (duplex or multiplex models available).

Capacity adjustment: Manual over full flow range with micrometer dial. Available for most models with pneumatic or electrical stroke adjustment for remote or automatic control. Variable speed drives also available.

Discharge pressure: To 7,500 psi.

Accuracy: ±1%

Dimensions: (approximate, less motor and liquid end).

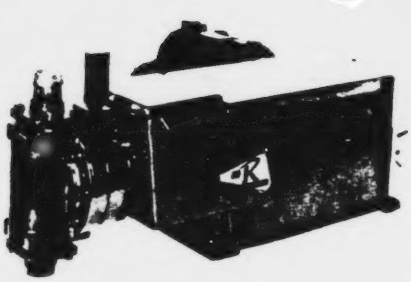
Models A & B: 8″ wide, 11″ high, 27″ deep.

Model C: 13″ wide, 18″ high, 48″ deep.

Construction: Cast iron, cast steel, 316 stainless steel, Milroy stainless steel (similar to Carpenter 20) alloys HB and HC, a special construction for concentrated H_2SO_4 and PVC plastic.

Technical details covered in Bulletin 35. When requesting quotation, please state fluid to be pumped, capacity (GPH), and discharge pressure (PSI) required.

U.S. Patent Numbers 3, 075, 613; 2 892, 352



Milroyal® with Tubular Diaphragm Liquid End

This totally new elliptical tubular diaphragm liquid end offers the benefits of increased versatility in handling heavy slurries, a double diaphragm for greater safety in pumping toxic and corrosive chemicals, and the most advanced tubular diaphragm design available combined with the proven Milroyal drive.

Capacity: 0.2 to 79.8 gph (duplex or multiplex units available).

Capacity adjustment: Manual over full flow range with micrometer dial. Available with pneumatic or electrical stroke adjustment for remote or automatic control. Variable speed drives also available.

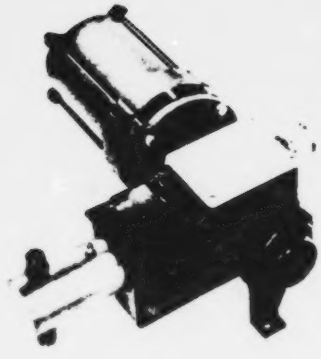
Discharge pressure: To 1,000 psi.

Accuracy: ±1.7%.

Dimensions: (approximate, less motor and liquid end).

Models A & B: 8″ wide, 11″ high, 27″ deep.

Construction: High tensil cast iron diaphragm head and displacement chamber. Polyurethane disc diaphragm. Hypalon and Viton tubular diaphragms available. Ask for Bulletin 35 for more details.



Milroyal® D Controlled Volume Pump

A small capacity ruggedized pump for industrial or laboratory use. Has polar crank drive featured in larger capacity Milroyals and is totally enclosed with all drive parts operating in oil. Up to six units can be multiplexed with a single drive motor.

Specifications: Maximum Capacities and Pressures

Plunger Diameter	Strokes Per Minute				Discharge Pressures
	30	60	117	175	
1/8″	308	615	1200	1300 ml/hr	1000 PSIG
1/4″	1230	2460	4800	7150 ml/hr	1000 PSIG
7/16″	1.0	2.0	4.1	6.1 gal/hr	1000 PSIG
5/8″	2.1	4.2	8.4	12.5 gal/hr	850 PSIG

Dimensions: (approximate)

11″ wide, 8″ high, 13½″ deep, including standard drive.

For complete technical data and prices, ask for Bulletin 36 and a quotation based on your specific requirements.

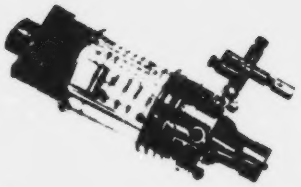
U.S. Patent Numbers 3,075,613; 2,892,352

LOOK INTO MILTON ROY...

Accessories

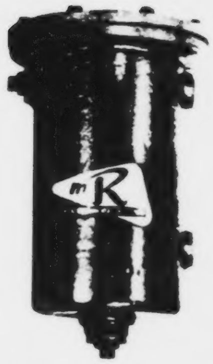
Electric Capacity Controls

Available for Milroyal® A and B and mRoy® A and B pumps. Positions stroke length within ±2%. Control signal is derived from remote manual control or from process monitor.



Pneumatic Capacity Controls

Automatically vary pump capacity in response to standard 3-15 psi instrument air signal or other standard ranges, such as 3-27 psi and various split ranges. Provides accurate, automatic linear adjustment in both directions. Available for most models of mRoy and Milroyal pumps.



Sludge Trap

Eliminates sludge from concentrated sulfuric acid. Capacities to 20 gph. Protects precision controlled volume pumps to maintain accuracy and efficiency. Settling chamber for large particles, ceramic ball prefilter and replaceable fiberglass final filter. Bottom drain for easy cleaning. Cast iron casing. Teflon* gasket. For further information, request Bulletin 459.

Teflon* Diaphragm Safety and Back-Pressure Valve

Economical, leakproof, and corrosion-resistant. Designed to protect pump and discharge lines from high pressure damage. Sizes from ¼" to 1"; relieve at pressures to 1500 psi; back pressures at 200 psi. Materials contacting liquids are low-carbon steel, CA-20, and alloys HB and HC or PVC. Teflon* diaphragms isolate operating parts from liquid. Ask for Bulletin 55 for further information.

Variable Speed Motors

For manual or automatic control of pump stroking speed when it is not essential to accurately control pump delivery down to zero flow rate. Often used in proportional feed systems to maintain proportional rate where dosage rate is controlled separately by stroke adjustment.

*A DuPont registered trademark.

For complete details on all accessories, please contact your nearest Milton Roy sales office.

with these Milton Roy water quality analyzers standing guard

Whatever water quality condition you need to monitor, Milton Roy builds an analyzer package to give you rapid, accurate data, repeatedly or continuously.

Then we combine the analyzer system with all the related equipment it takes to make a complete water quality control package for your specific application: all the sample extraction, sample conditioning, pumping and flow control devices, recorders and indicators, signals and activators.

And when it's all done, everything is fully compatible, because we made all the major components and instrumentation. To minimize your investment and simplify maintenance, the system embodies the simplest design that will do the total job, but the most advanced technology in every component.

YOU CAN FEEL SECURE ABOUT YOUR BOILER AND PROCESS WATER

When you have to be sure that your boiler or process water meets critical specifications, see your Milton Roy representative.

MILTON ROY
INDUSTRIES LTD.
PETERBOROUGH, ONTARIO

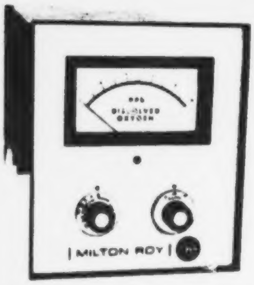
SODIUM
MILTON ROY

Sodium Ion Analyzer
Offers eight calibrated ranges, lets you read concentrations from .1 ppb to 100,000 ppm by simply turning a dial. Automatic temperature compensation control. Low noise pick-up. Simultaneous current and voltage output available.

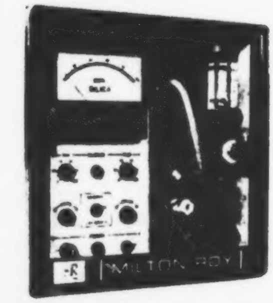
Hydrogen Ion Analyzers
A rugged, high-quality instrument designed to measure pH in chemical processes, wastewater treatment or cooling towers. Simultaneous current and potentiometric outputs. Low noise pick-up. Fixed range or multi-ranges available. Simultaneous on-off control and dual alarms. Full line of sturdy electrode assemblies. Also furnished in a weather-resistant (NEMA-4) housing.

SPECIFIC CONDUCTANCE

Conductivity Analyzers
A durable instrument designed for monitoring total dissolved solids in many industrial applications. Features improved bridge design, high frequency oscillator, manual or automatic temperature compensation, simultaneous on-off control and dual alarms. Simultaneous current and voltage outputs available.



Dissolved O_2 Analyzers
Provide the rapid and accurate measurements you need to minimize corrosion damage, downtime and maintenance costs on boiler and pre-boiler systems. Models for low pressure boilers where sample conditioning is not available and sample temperatures are under 150° C, and for medium and high pressure boilers with operating sample temperatures of 5° to 50° C.



Colorimetric Analyzers
For continuous, on-stream batch analysis of silica content, or hardness, or phosphate content. Fast, sensitive and economical. Built for the easiest maintenance ever required of a colorimetric analyzer. Easy to keep pinpoint calibration. Total analysis completed in 5 minutes or less.

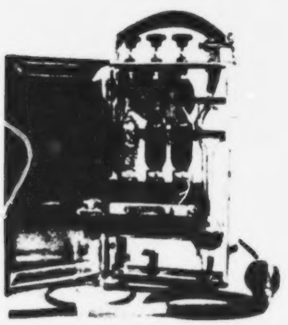
When lower fuel consumption is critical to costs & conservation, you need a choice of dependable O_2 stack gas analyzers!

Everyone knows that air, with its oxygen content, is necessary to the combustion process. But that too much air merely carries costly, unproductive heat up the stack. Too little air results in incomplete combustion of the fuel and contributes to the atmospheric pollution problem. By monitoring oxygen, either continuously or intermittently, a predetermined, optimum fuel/air ratio for most economical combustion and heat generation can be maintained.

Only Hays-Republic offers you *five* types of accurate, dependable analyzers to answer just about any O_2 monitoring need. From a low-cost, portable, chemical unit to the most sophisticated *in situ* continuous analyzer, we make them all. So when you want to meet the fuel cost crunch or a possible fuel shortage situation head-on, come to the people who can give you a choice of methods. The people who pioneered O_2 monitoring for most efficient combustion.

ONLY HAYS-REPUBLIC OFFERS YOU ALL FIVE WAYS TO MONITOR O_2

MILTON ROY
INDUSTRIES LTD.
PETERBOROUGH, ONTARIO

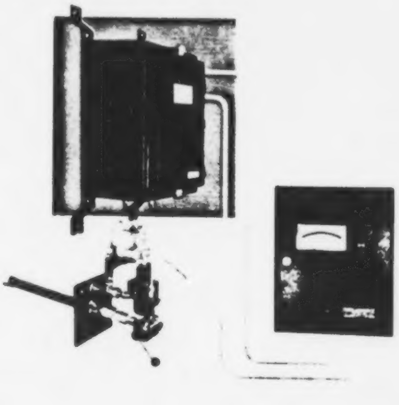


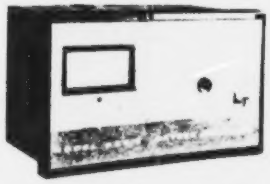
1. Model A-00621A Portable Orsat Oxygen Analyzer.
Light, compact, easy-to-carry. Accurately measures O_2, CO_2 and CO concentrations. Use independently to monitor flue gas concentrations or to calibrate continuous analyzers. Simple to operate and maintain. Four standard models.

2. Model A-62301 Portable Electrochemical Oxygen Analyzer.
Requires no power and is unaffected by CO_2. Multiple ranges of 0 to 5%, 0 to 10% and 0 to 25% O_2. Fast response. Compact and complete with own sampling pump. Jacks available for 0 to 25 mV output.

3. Model A-10007 In Situ ZrO_2 Stack Probe Analyzer.
Low initial cost, easy to maintain and field service. Accurate over four measurement ranges. No sampling system required. Fast, in-place calibration. Only a single electronic unit and compact temperature controller required. Standard linear and mV outputs to recorders and controllers.

4. Model A-00671 ZrO_2 Continuous O_2 Analyzer.
Stack-mounted analyzer and remote electronics unit provide analog signal to receivers, recorders and controllers. No sample conditioning required. Positive indication of flow sample. Multi-range. Maximum flexibility of installation. Fast response. Easy to install, operate and calibrate. Rugged construction.





5. Model A-00635 Paramagnetic Oxygen Analyzer
Analyzes and indicates O_2 content of measured gas mixture. Solid-state electronics design for high reliability, minimum maintenance, easy calibration and fast response. Dual ranges offered, as well as explosion proof models. Use with recorders, indicators and controllers for a total O_2 system.

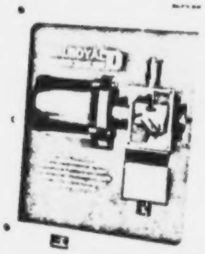
need more information?

mROY CONTROLLED VOLUME PUMPS

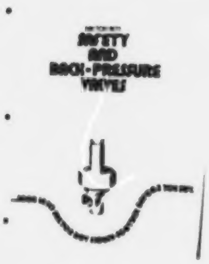
MRoy Controlled Volume Pumps, describes mRoy line of controlled volume pumps and information on packaged chemical feed systems, control devices and accessories. Request Bulletin 15.001.

MILROYAL CONTROLLED VOLUME PUMPS

Milroyal Controlled Volume Pumps, describes the Milroyal line of controlled volume pumps. Information given on liquid ends, controls, operation, capacities, pressures and dimensions. Request Bulletin 35.001.



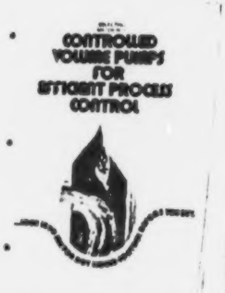
Milroyal D Controlled Volume Pump, describes features and specifications for this compact controlled volume pump. Request Bulletin 36.001.


SAFETY AND BACK-PRESSURE VALVES

Safety Valves and Back Pressure Valves. Bulletin gives description and specifications for Milton Roy safety and back pressure valves. Request Bulletin 55.001.

SLUDGE TRAP

Milton Roy Sludge Trap. Bulletin describing how Milton Roy sludge trap can prevent sludge build-up when metering sulfuric acid. Request Bulletin 459.


CONTROLLED VOLUME PUMPS FOR EFFICIENT PROCESS CONTROL

Selecting Milton Roy Controlled Volume Pumps For Efficient Process Control, explains the principles of metering pumps. Request Bulletin 100.

MILTON ROY

INDUSTRIES LTD.

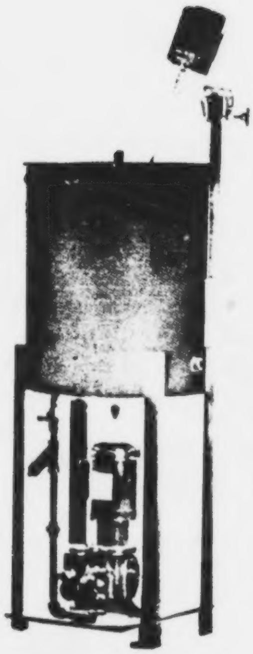
PETERBOROUGH, ONTARIO

mR TECHNOLOGY IN FLUIDS

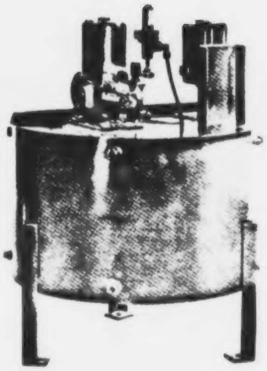
15M978

LOOK INTO MILTON ROY...

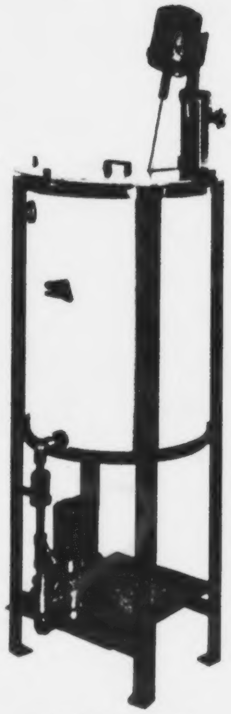
Packaged Chemical Feed Systems



100 gallon stainless steel tank with bottom mounted mRoy B simplex pump and motor operated agitator.



50 gallon stainless steel tank with top mounted mRoy simplex pump. Features agitator and safety valve.

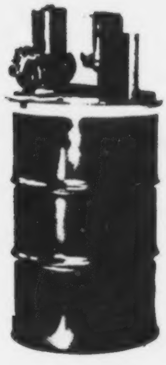


Bottom mounted mRoy A simplex pump with 55 gallon polyethylene tank mounted on angle legs.

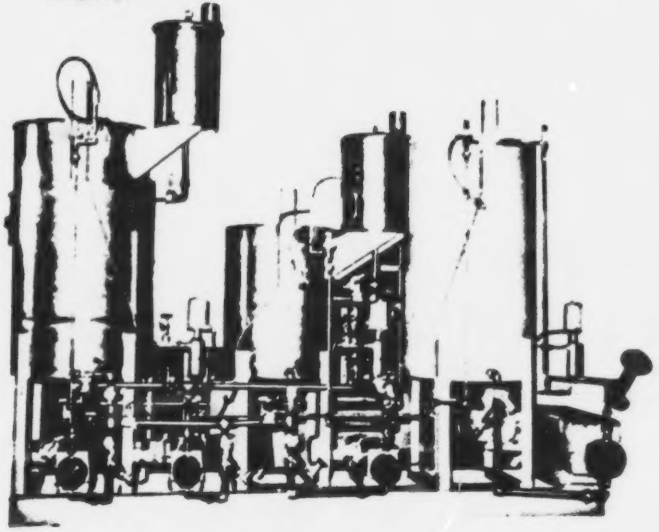
Packaged chemical feed systems are self-contained units which include the totally enclosed mRoy® or Mil-Royal® controlled volume pump of your choice, mounted on steel, stainless steel, plastic or plastic lined chemical solution tanks. The tanks are available with hinged covers and agitator mounting brackets. Suction piping and strainers are assembled and piped so that the system is ready to install upon arrival. A complete line of accessories is available to tailor the system to meet specific requirements.

A number of standard packaged systems are available to choose from. If none of these systems suit your requirements, Milton Roy Company will engineer a system to your exact specifications.

For details on packaged chemical feed systems, please contact your nearest Milton Roy Sales Office or representative.



Frame A mRoy pump top mounted on a poly-lined steel drum package with agitator.

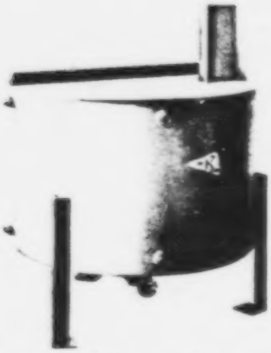


Complete packaged chemical feed control system, skid-mounted, featuring stainless steel tanks with bottom mounted Milroyal diaphragm pumps.

LOOK INTO MILTON ROY...

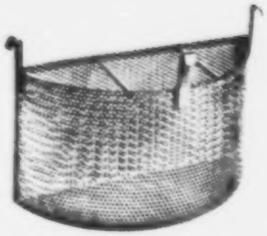
Accessories

Milton Roy Company can supply accessories to make packaged chemical feed systems more effective and useful in every application.

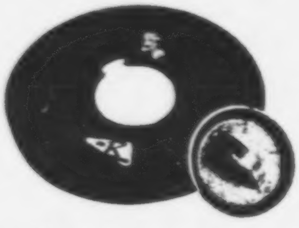


Chemical Solution Tanks
Steel, stainless steel, plastic and plastic lined chemical solution tanks are offered in capacities from 50 to 1000 gallons. 50 and 100 gallon sizes are available from stock.

Starting Switches
Toggle type motor starting switches with overload protection suitable for pump or agitator motors. Single phase, 60 Hz, 115 VAC. Magnetic starters are available for 3-phase motors.



Dissolving Baskets
Dissolving baskets for holding dry chemicals while they are being dissolved. Steel, 304 SS and 316 SS baskets are available.



Donut Floats
Steel and polystyrene floats are available to prevent air from contacting surface of liquid in tank.

Agitators
Motor-operated agitators with stainless steel shafts and propellers. Equipped with 1/4 or 1/3 HP, single phase, 60 Hz, 115 VAC motors. Operates in 50 to 250 gallon tanks. Other motor characteristics are available.

For details please contact your nearest
Milton Roy Sales Office or representative.

MILTON ROY COMPANY
Flow Control Division
201 Ivyland Road ☐ Ivyland, Pa. 18974 ☐ (215) 441-0800 ☐ Telex 083-4348

Copyright© 1979, Milton Roy Company
Duplication of any part of this bulletin requires written approval by Milton Roy Company.

	FLASH POINT °F(°C)	IGNITION TEMP. °F(°C)	FLAMMABLE LIMITS Percent by Vol. Lower	Upper	Sp. Gr. (Water = 1)	Vapor Density (Air = 1)	BOILING POINT °F(°C)	Water Soluble	EXTINGUISHING METHOD See Intro.	SUGGESTED HAZARD IDENTIFICATION Health	Flamma-bility	Reac-tivity
Jet Fuels JP—4	− 10 to + 30 (− 23 to − 1)	464 (240)	1.3	8.0						1	3	0
Jet Fuels JP—5	95-145 (35-63)	475 (246) (approx.)								0	2	0
Jet Fuels JP—6	100 (38) (oc)	446 (230)	0.6	3.7	0.8	< 1	250 (121)	No				
Katchung Oil	See Peanut Oil (cooking).											
[illegible]	[illegible]											
Kerosene, Deodorized	See Ultrasene.											
Lactonitrile $CH_3CH(OH)CN$	171 (77)				0.98	2.45	361 (183)	Yes		4	2	1
Lanolin (Wool Grease)	460 (238)	833 (445)			< 1			No	Water or foam may cause frothing.	0	1	0
Lard Oil (Commercial or Animal) No. 1	395 (202) (Und. Lab. Class 10-20) 440 (227)	833 (445)			< 1			No	Water or foam may cause frothing.	0	[illegible]	0
Lard Oil (Pure) No. 2 Mineral	500 (260) 419 (215) 404 (207)				0.9			No	Water or foam may cause frothing.	0	1	0
Lauryl Alcohol	See 1—Dodecanol											
Lauryl Bromide $CH_3(CH_2)_{10}CH_2Br$ (Dodecyl Bromide)	291 (144)				1.0+		356 (180) @ 45 mm	No	Water or foam may cause frothing.	1	1	0
Lauryl Mercaptan	See 1—Dodecanethiol											
Linalool (Ex Bois de Rose; Synthetic) $(CH_3)_2C{:}CHCH_2CH_2C(CH_3)$- $OHCH{:}CH_2$ (3,7—Dimethyl—1,6—Octa-diene—3—Ol)	160 (71)				0.9		383-390 (195-199)	No	"Alcohol" foam		2	0
Linseed Oil, Raw Boiled	432 (222) 403 (206)	650 (343)			0.9		600+ (316+)	No	Water or foam may cause frothing.	0	1	0
Liquid Camphor	See Camphor Oil (light).											
Lubricating Oil, Mineral (Paraffin Oil, includes Motor Oil)	300—450 (149-232)	500—700 (260-371)			< 1		680 (360)	No	Water or foam may cause frothing.	0	1	0
Lubricating Oil, Spindle (Spindle Oil)	169 (76)	478 (248)			< 1			No		0	2	0
Lubricating Oil, Turbine (Turbine Oil)	400 (204) (oc)	700 (371)			< 1			No	Water or foam may cause frothing.	0	1	0
Lynalyl Acetate (Ex Bois de Rose; Synthetic) $(CH_3)_2C{:}CHCH_2CH_2$- $C(-OOCCH_3)CH{:}CH_2$ (Bergamol)	185 (85)				0.9		226-230 (108-110)	No	"Alcohol" foam		2	0
Maleic Anhydride $(COCH)_2O$	215 (102) Note: Melting point 127 (53). See Hazardous Chemicals Data	890 (477)	1.4	7.1	0.9		396 (202)	Slight	"Alcohol" foam. Water or foam may cause frothing.	3	1	[illegible]
Marsh Gas	See Methane.											
Menhaden Oil (Pogy Oil)	435 (224)	828 (442)			0.9			No	Water or foam may cause frothing.	0	1	0

	FLASH POINT °F(°C)	IGNITION TEMP. °F(°C)	FLAMMABLE LIMITS Percent by Vol.		Sp. Gr. (Water = 1)	Vapor Density (Air = 1)	BOILING POINT °F(°C)	Water Soluble	EXTINGUISHING METHOD See Intro.	SUGGESTED HAZARD IDENTIFICATION		
			Lower	Upper						Health	Flammability	Reactivity
Ethyl Propyl Ether $C_2H_5OC_3H_7$ (1—Ethoxypropane)	< -4 (< -20)		1.7	9.0	0.8		147 (64)	Yes	"Alcohol" foam.	1	3	0
Ethyl Silicate $(C_2H_5)_4SiO_4$ (Ethyl Orthosilicate) (Tetraethyl Orthosilicate)	125 (52) (oc)				0.9	7.2	334 (168)	Decomposes		2	2	0
Ethyl Sulfate	See Diethyl Sulfate.											
Ethyl Sulfhydrate	See Ethyl Mercaptan.											
m—Ethyltoluene $CH_3C_6H_4C_2H_5$ (1—Methyl—3—Ethylbenzene)		896 (480)			0.88	4.15	322 (161)				2	0
o—Ethyltoluene $CH_3C_6H_4C_2H_5$ (1—Methyl—2—Ethylbenzene)		824 (440)			0.88	4.15	329 (165)				2	0
p—Ethyltoluene $CH_3C_6H_4C_2H_5$ (1—Methyl—4—Ethylbenzene)		887 (475)			0.88	4.15	324 (162)				2	0
Ethyl p—Toluene Sulfonamide $C_7H_7SO_2NHC_2H_5$	260 (127)				1.3		208 (98) @ 745 mm		Water or foam may cause frothing.		1	0
Ethyl p—Toluene Sulfonate $C_7H_7SO_3C_2H_5$	316 (158)				1.2		345 (174)	No	Water or foam may cause frothing.		1	0
Ethyltrichloro Silane $CH_3CH_2SiCl_3$	72 (22) (oc)				1.2		208 (98) @ 743 mm		Water may be ineffective.	3	3	0
Ethyl Vinyl Ether	See Vinyl Ethyl Ether.											
Ethyne	See Acetylene.											
Fish Oil	420 (216)							No	Water or foam may cause frothing.	0	1	0
Fluorobenzene C_6H_5F	5 (-15)				1.03	3.31	185 (85)				3	0
Formal	See Methylal.											
Formalin	See Formaldehyde.											
Formaldehyde HCHO	Gas	795 (424)	7.0	73		1.0	-3 (-19)	Yes	Stop flow of gas.	2	4	0
37%, Methanol-free	185 (85)						214 (101)		"Alcohol" foam.	2	2	0
37%, 15% Methanol (Formalin) (Methylene Oxide)	122 (50) Note: See Hazardous Chemicals Data.									2	2	
Formamide $HCONH_2$	310 (154) (oc)				1.1		410 (210) Decomposes	Yes	Water or foam may cause frothing.	2	1	
Formic Acid HCOOH	156 (69)	1004 (539)			1.2	1.6	213 (101)	Yes	"Alcohol" foam.	3	2	0
90% Solution	122 (50) Note: See Hazardous Chemicals Data.	812 (434)	18	57								
Formic Acid, Butyl Ester	See Butyl Formate.											
Formic Acid, Ethyl Ester	See Ethyl Formate.											
Formic Acid, Methyl Ester	See Methyl Formate.											
[redacted] (Range Oil) (Coal Oil)	110-162 (43-72)	410 (210)	0.7	5	<1		304-574 (151-301)	No		0	[redacted]	0
Fuel Oil No. 2	126-204 (52-96)	494 (257)			<1			No		0	2	0
Fuel Oil No. 4	142-240 (61-116)	505 (263)			<1			No		0	2	0

	FLASH POINT °F(°C)	IGNITION TEMP. °F(°C)	FLAMMABLE LIMITS Percent by Vol.		Sp. Gr. (Water = 1)	Vapor Density (Air = 1)	BOILING POINT °F(°C)	Water Soluble	EXTINGUISHING METHOD See Intro.	SUGGESTED HAZARD IDENTIFICATION		
			Lower	Upper						Health	Flamma-bility	Reac-tivity
3—Methylhexane $CH_3CH_2CH(CH_3)CH_2CH_2CH_3$	25 (−4)	536 (280)			0.69	3.46	198 (92)			0	3	0
Methyl Hexyl Ketone $CH_3COC_6H_{13}$ (2—Octanone)	125 (52)				0.8	4.41	344 (173.5)	No	"Alcohol" foam.	0	2	0
Methylhydrazine CH_3NHNH_2	17 (−8)	382 (194)	2.5	92	0.9	1.6	190 (88)	Slight	Water may be ineffective. "Alcohol" foam.	3	3	1
Methyl—3—Hydroxybutyrate $CH_3CHOHCH_2COOCH_3$	180 (82) (oc)				1.1	4.1	347 (175)	Yes	"Alcohol" foam.	1	2	0
Methyl Ionone $C_{14}H_{22}O$ (Irone)	>212 (>100)				0.9		291 (144) @ 16 mm	No	"Alcohol" foam.	0	1	0
Methyl Isoamyl Ketone $CH_3COCH_2CH_2CH(CH_3)_2$	96 (36)	375 (191)	1.0 @ 200 (93)	8.2 @ 200 (93)	0.8	3.9	294 (146)	No		1	2	0
[redacted] (1, 3—Dimethylbutanol) (4—Methyl—2—Pentanol) (Methylamyl Alcohol)	106 (41)		1.0	5.5	0.8		266-271 (130-133)	Slight	"Alcohol" foam.	2	2	0
Methylisobutylcarbinol Acetate	See 4—Methyl—2—Pentanol Acetate.											
Methyl Isobutyl Ketone $CH_3COCH_2CH(CH_3)_2$ (Hexone) (4—Methyl—2—Pentanone)	64 (18)	840 (448)	1.2 @ 200 (93)	8.0 @ 200 (93)	0.8	3.5	244 (118)	Slight	"Alcohol" foam. Water may be ineffective.	2	3	0
Methyl Isopropenyl Ketone $CH_3COC{:}CH_2(CH_3)$			1.8	9.0		2.9	208 (98)			2		0
Methyl Isocyanate CH_3NCO (Methyl Carbonimide)	19 (−7)	994 (534)	5.3	26	1.0−	1.97	102 (39)	Yes	"Alcohol" foam.	3	3	2W
Methyl Iso Eugenol $CH_3CHCHC_6H_3(OCH_3)_2$ (Propenyl Guaiacol)	>212 (>100)				1.1		504-507 (262-264)	No	"Alcohol" foam.	0	1	0
Methyl Lactate $CH_3CHOHCOOCH_3$	121 (49) (Und. Lab. Class 30-35)	725 (385)	2.2 @ 212(100)		1.1	3.6	293 (145)	Yes Decomposes		1	2	0
Methyl Mercaptan CH_3SH (Methanethiol)			3.9	21.8	0.9	1.7	42.4 (6)	Yes	"Alcohol" foam.	2	4	0
β Methyl Mercaptopropionaldehyde $CH_3SC_2H_4CHO$ (3—(Methylthio) Propionaldehyde)	142 (61)	491 (255)			1.03	3.60	~329 (~165)				2	0
Methyl Methacrylate $CH_2{:}C(CH_3)COOCH_3$	50 (10) (oc) Note: Polymerizes. See Hazardous Chemicals Data		1.7	8.2	0.9	3.6	212 (100)	Very slight	Water may be ineffective.	2	3	2
Methyl Methanoate	See Methyl Formate.											
4—Methylmorpholine $C_2H_4OC_2H_4NCH_3$	75 (24)				0.9	3.5	239 (115)	Yes	Water may be ineffective. "Alcohol" foam.	2	3	0
1—Methylnaphthalene $C_{10}H_7CH_3$		984 (529)			1.04		472 (244)	No		2	2	0
Methyl Nonyl Ketone $C_9H_{19}COCH_3$	192 (89)				0.8 @ 86 (30)	5.9	433 (223)	No		0	2	0
Methyl Oxide	See Methyl Ether.											
Methyl Pentadecyl Ketone $C_{15}H_{31}COCH_3$	248 (120)						313 (156) @ 3 mm	No	Water or foam may cause frothing.	0	1	0
2—Methyl—1, 3—Pentadiene $CH_2{:}C(CH_3)CH{:}CHCH_3$	<−4 (<−20)				0.72	2.83	169 (76)			0	3	0

als, and in 1961 a *Recommended System for*
re Hazards of Materials, NFPA 704, was
nd revised in 1964, 1966, 1969, and 1975

tem provides simple, readily recognizable
narkings which will give at a glance a
ent hazards of any material and the order
rds as they relate to fire prevention, expo-
objectives are to provide an appropriate
ne-spot information to safeguard the lives
te fire fighting personnel during fire emer-
t in planning for effective fire fighting op-
d by plant design engineers and plant pro-
nel.

he hazards of a material in terms of three
alth," "Flammability" and "Reactivity"
of severity in each of these categories by
om "four (4)" indicating a severe hazard
no special hazard. The three categories
ying approximately 35 inherent and en-
materials which could affect fire fighting
grees were decided upon as necessary to
nation. It was also felt that for such a
had to be relatively simple and readily

asically simply in application, the hazard
ired for the precise use of the signals in a
made by experienced, technically compe-
ment must be based on factors encompas-
inherent hazards of different materials,
hange in behavior to be anticipated under
e and control.

The columns under "Suggested Hazard Identification" in the listing of materials give the degrees of hazard severity for each category where information was available. Spaces were left blank where adequate information was not available. It should be emphasized that the assignment of degrees is based on judgment and that conditions in plants or processes

might change the degrees of hazard. If any user of this publication has additional information on any of the materials listed, it would be appreciated if he would send it to the NFPA.

The following discussions on degrees of hazard are an interpretation of the information contained within NFPA 704 and are related specifically to the fire fighting aspects. Refer to NFPA 704 for a detailed discussion of the identification system.

Health.

In general, health hazard in fire fighting is that of a single exposure which may vary from a few seconds up to an hour. The physical exertion demanded in fire fighting or other emergency conditions may be expected to intensify the effects of any exposure. Only hazards arising out of an inherent property of the material are considered. The following explanation is based upon protective equipment normally used by fire fighters.

4 Materials too dangerous to health to expose fire fighters. A few whiffs of the vapor could cause death or the vapor or liquid could be fatal on penetrating the fire fighter's normal full protective clothing. The normal full protective clothing and breathing apparatus available to the average fire department will not provide adequate protection against inhalation or skin contact with these materials.

3 Materials extremely hazardous to health but areas may be entered with extreme care. Full protective clothing, including self-contained breathing apparatus, coat, pants, gloves, boots, and bands around legs, arms and waist should be provided. No skin surface should be exposed.

[illegible] Materials hazardous to health, but areas may be entered freely with full-faced mask self-contained breathing apparatus which provides eye protection.

1 Materials only slightly hazardous to health. It may be desirable to wear self-contained breathing apparatus.

0 Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

mmability.

Susceptibility to burning is the basis for assigning degrees within this category. The method of attacking the fire is influenced by this susceptibility factor. For further information on this subject, refer to the column on "Extinguishing Method" and to its explanation on pages 8-11.

4 Very flammable gases or very volatile flammable liquids. Shut off flow and keep cooling water streams on exposed tanks or containers.

3 Materials which can be ignited under almost all normal temperature conditions. Water may be ineffective because of the low flash point.

[illegible] Materials which must be moderately heated before ignition will occur. Water spray may be used to extinguish the fire because the material can be cooled below its flash point.

1 Materials that must be preheated before ignition can occur. Water may cause frothing if it gets below the surface of the liquid and turns to steam. However, water fog gently applied to the surface will cause a frothing which will extinguish the fire.

0 Materials that will not burn.

Reactivity (Stability).

The assignment of degrees in the reactivity category is based upon the susceptibility of materials to release energy either by themselves or in combination with water. Fire exposure was one of the factors considered along with conditions of shock and pressure.

4 Materials which (in themselves) are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. Includes materials which are sensitive to mechanical or localized thermal shock. If a chemical with this hazard rating is in an advanced or massive fire, the area should be evacuated.

3 Materials which (in themselves) are capable of detonation or of explosive decomposition or of explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. Includes materials which are sensitive to thermal or mechanical shock at elevated temperatures and pressures or which react explosively with water without requiring heat or confinement. Fire fighting should be done from an explosion resistant location.

APPENDIX 3

Sala Pump Data

Slurry pumps

Vertical type

Leaflet 207 E

SALA

SALA VERTICAL PUMP type SPV

is a special type of centrifugal pump originally developed to handle flotation froth. The pump also had to accept variations in the feed without trouble which is important in a mineral dressing plant where the process may be changed frequently. The vertical pump solved these problems in an excellent way. Now **an improved design** of this pump is used in many industries where slurry pumping is a problem.

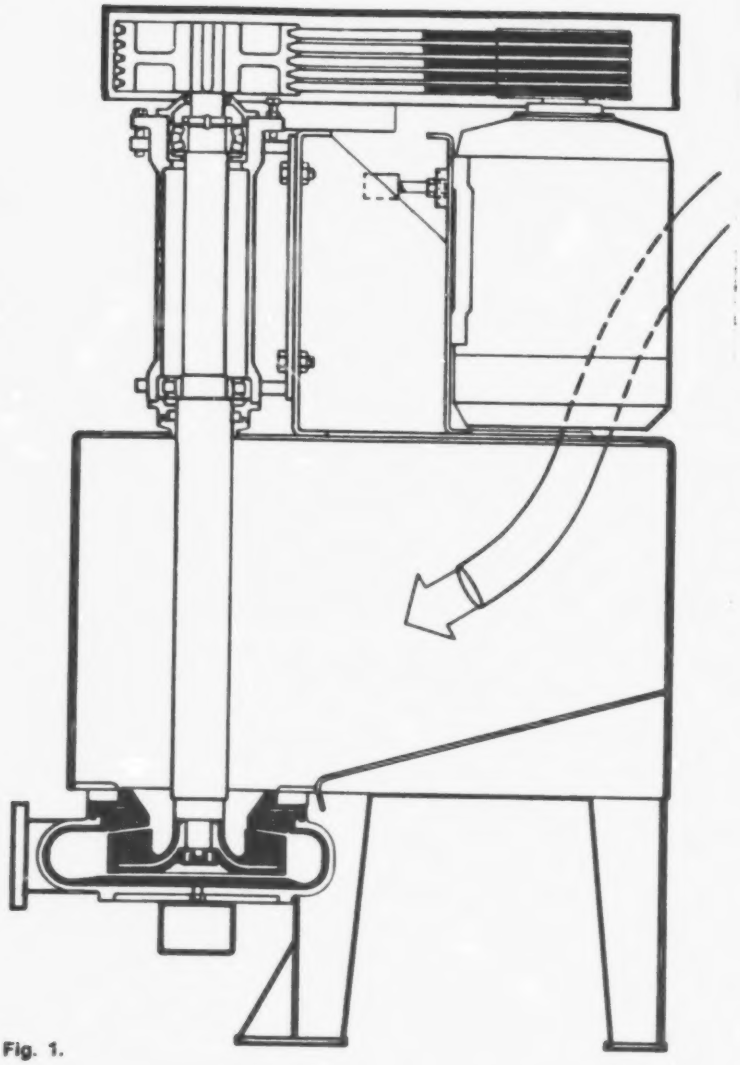


Fig. 1.

EASY TO INSTALL

The pump, sump and motor are a self-contained unit supported on 4 legs The housing can be rotated to provide the position required for the discharge

V-BELT DRIVE

to facilitate setting of impeller speed to the capacity and head required

STANDARD SQUIRREL CAGE INDUCTION MOTOR

The power requirements can be obtained from the pump curves.

ADJUSTABLE MOTOR BASE

SELF REGULATING

At high level the pump works at full capacity – at low level air is sucked in with the slurry and decreases the capacity.

INDEPENDENT OF SURGES IN THE FEED

The vertical inlet to the pump housing prevents air from blocking the impeller which can happen when a conventional pump runs dry.

SIMPLIFIED MAINTENANCE

No nuts or bolts – the wearing parts can be changed very quickly by removing two wedges that secure the beam supporting the pump casing. On the larger pumps the beam can be swung out as illustrated on page three.
On the small SPV-180 the housing is secured by two bolts.

NO LEAKAGE

NO STUFFING BOXES

– Simplified maintenance and no friction heat when idling.

PUMP SUMP AND SHAFT

– These parts are normally supplied in carbon steel but if required of stainless steel or rubber covered. All wetted areas in the pump can be protected against corrosive slurries.

The cover picture shows pumps of the SPV 304-4 type, which are installed in a concentration plant for copper ore.

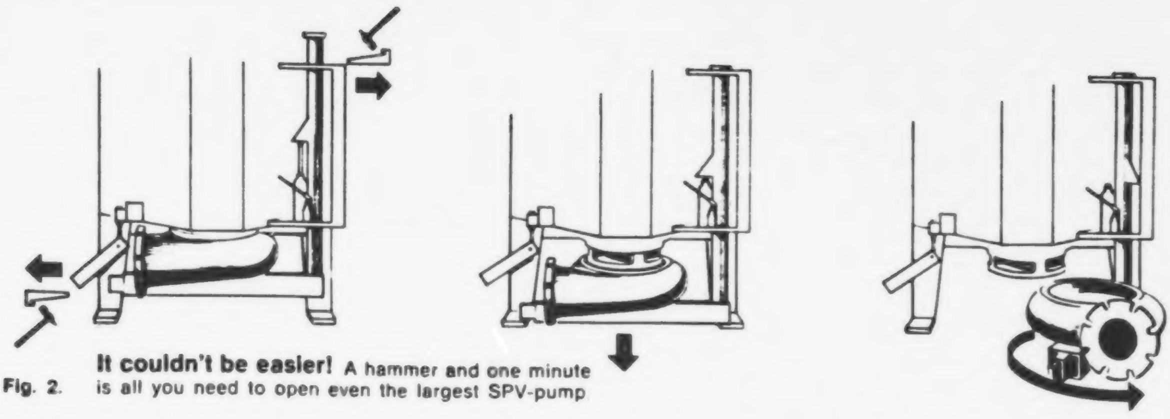


Fig. 2. **It couldn't be easier!** A hammer and one minute is all you need to open even the largest SPV-pump

Selection of wear parts

Wear parts can be selected to suit slurry being handled. Wear parts of various materials are interchangeable and consequently most economical material can be determined by trial.

- **Natural Rubber** – suitable for fine material (less than $^1/_8$"). This rubber is vulcanized onto the pump housing and impeller. In some pumps exchangeable moulded linings for the casing are available. Rubber is not suitable where oil is present or where temperature exceeds 60°C (140°F).
- **Ni-Hard** – Ni-Cr-alloyed cast iron has excellent abrasive resistant qualities and can be used for coarse material and where rubber cannot be used for other reasons.
- **Stainless or acid proof steel** – can be used where abrasion is mild.
- **Silicon carbide** has excellent abrasion and corrosion resistance but are quite brittle.

Wear parts in the vertical pump

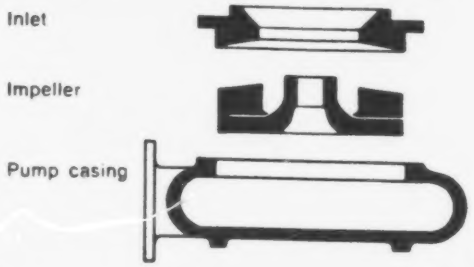
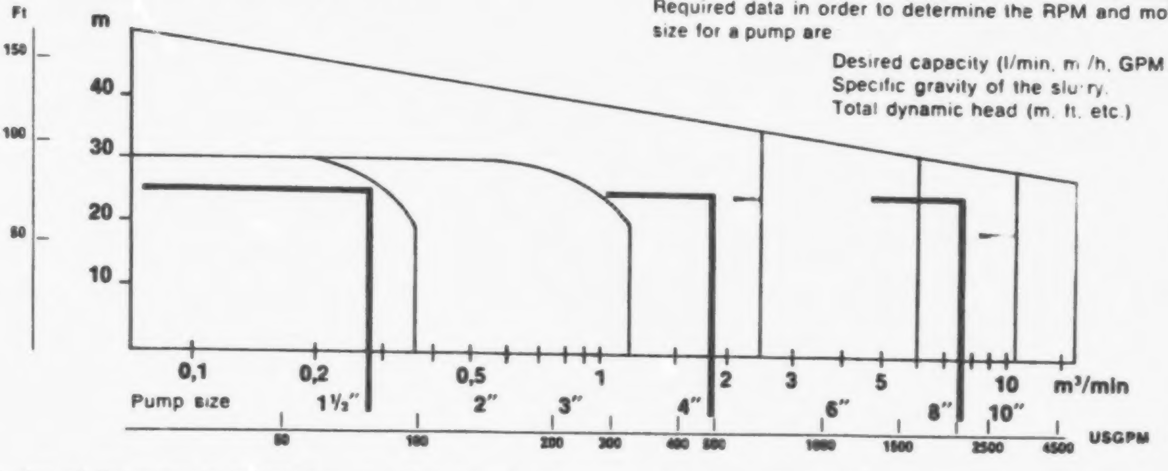


Fig. 3.

Selection of pump size



The size of the pump is indicated by the diameter of the discharge end, in inches.

The coloured areas in the graph show the maximum operating range. The incided angles indicate the ranges of work for abrasive service.

When ordering several pumps for one and the same plant the self-regulating feature of the SPV pumps should be kept in mind. The selection of an oversize type for some of the pumps will make it possible to standardize on one and the same size and speed for all the pumps and pump motors. With frothy pulp, the selected capacity must be multiplied with a certain froth factor, which should never be less than 2.0. With viscous and sticky froths it is adviseable to choose a considerably higher figure.

Selection of motor size

Motor size and V-belt drive varies with the pump duty. Required data in order to determine the RPM and motor size for a pump are

Desired capacity (l/min, m³/h, GPM etc.)
Specific gravity of the slurry.
Total dynamic head (m, ft, etc.)

Dimensions

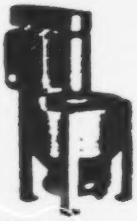
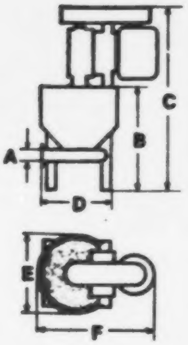


Fig. 4. SPV 180



Shaded areas on the dimension drawings denote open areas for feed inlet.

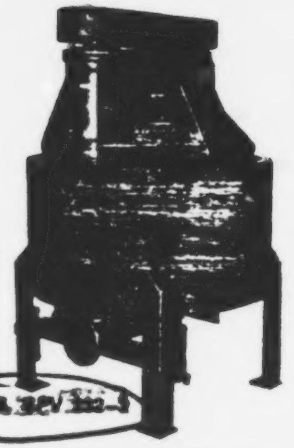


Fig. 6. SPV 232-2

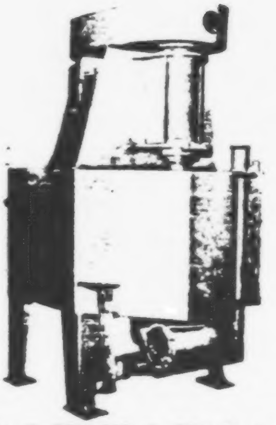
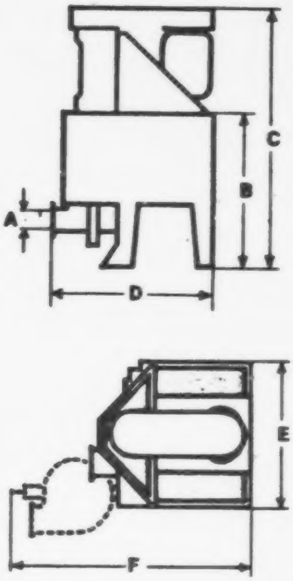
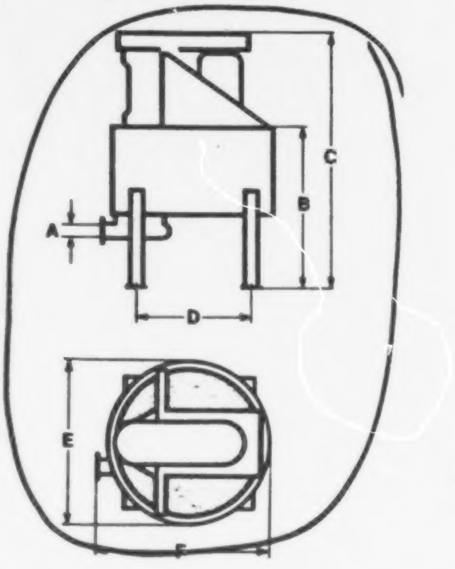


Fig. 5. SPV 263–3, SPV 304–4,
SPV 365–6, SPV 458–8,
SPV 5010–10





Type	Pump tank volume m³(cu.ft.)	Discharge, inches A	Space required approx mm (inches) B	C	D	E	F	Max motor HP	Approx weight without motor and V-drive kgs (lbs)	Dimension drawing No	Performance curve No
SPV 180	.03 (1.0)	1 1/2"	540 (21")	960 (38")	350 (14")	400 (16")	650 (26")	4	45 (100)	STM-2-184	STM-2-243
SPV 232-2	.3 (1.0)	2"	910 (36")	1450 (57")	645 (30")	930 (37")	990 (39")	10	290 (780)	STM-2-292	STM-2-297
SPV 263-3	.4 (12.4)	3"	990 (39")	1785 (70")	1025 (40")	1000 (39")		40	560 (1100)	STM-2-335	STM-2-229
SPV 304-4	.7 (22.0)	4"	1210 (48")	2000 (79")	1250 (49")	1140 (45")	1900 (75")	40	700 (1550)	STM-2-198	STM-2-203,-246
SPV 365-6	.7 (22.0)	6"	1210 (48")	2000 (79")	1300 (51")	1140 (45")	1900 (75")	50	825 (1840)	STM-2-198	STM-2-204,-230
SPV 458-8	2.0 (62.0)	8"	1850 (73")	3050 (120")	1750 (69")	1700 (67")	2650 (104")	125	2450 (5450)	STM-2-198	STM-2-205
SPV 5010-10	2.0 (62.0)	10"	1850 (73")	3050 (120")	1800 (71")	1700 (67")	2650 (104")	150	2600 (5790)	STM-2-198	STM-2-250

SALA

Sala International

S-733 00 Sala · Sweden · Tel. 0224/132 20
Telegrams: Salamachine · Telex 7536

APPENDIX 4

Speed Controller Data

TOSHIBA/HOUSTON
INTERNATIONAL CORPORATION

ESP-130 SERIES

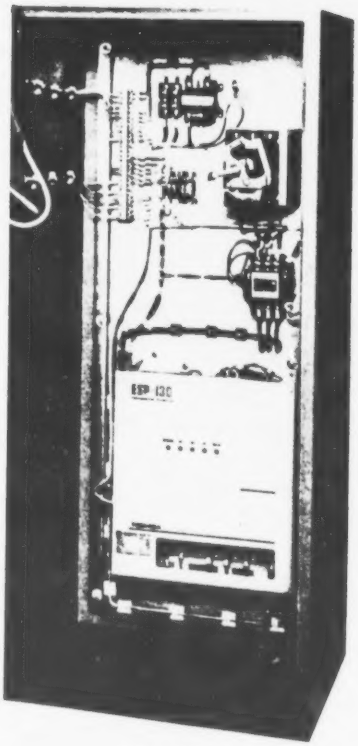
ADJUSTABLE SPEED DRIVE GENERAL PURPOSE TRANSISTORIZED INVERTER
1-100HP RATINGS

- Sinusoidal Pulse Width Modulation (PWM)
- Giant Transistor (G-TR) Technology
- Microcomputer Controlled
- Excellent Starting Characteristics
- Reduced Torque Pulsation
- 50/60 Hz Operation
- High Operational Efficiency
- Wide Speed Range (1:20) Constant Torque
- Variety of Options Available
- High Power Factor

TOSHIBA/HOUSTON has combined our broad experience in adjustable speed drives together with our excellent quality production capability in giant transistors, integrated circuits including the highly sophisticated microcomputer IC, printed circuit board assembly, and our long production and design experience in motor manufacturing to create the ESP-130 transistorized general purpose AC adjustable speed drive inverter. Coupled with an AC induction motor, the inverter can provide a variable speed system for greater productivity and energy savings.

ESP-130
TOSHIBA HOUSTON

VTG Series



ESP Series
(Built-up)

ESP-130
TRANSISTOR INVERTER
TOSHIBA

G-1 Series

TOSHIBA/HOUSTON
INTERNATIONAL CORPORATION

ESP-130 SERIES

ADJUSTABLE SPEED DRIVE GENERAL PURPOSE TRANSISTORIZED INVERTER

TOSHIBA/HOUSTON's ESP-130 Series Inverter is a sinusoidal PWM controlled voltage type inverter using Toshiba Giant Transistors (G-TR's) and Toshiba microcomputer technologies.

RATINGS

Model #	HP	3 Phase Voltage	KVA	Rated Current (A)
VT130G1-2010	¾	230	1.0	4
VT130G1-2015	1	230	1.5	5
VT130G1-4015	1	460	1.5	2.5
VT130G1-2025	2	230	2.5	7
VT130G1-4025	2	460	2.5	3.5
VT130G1-2035	3	230	3.5	10
VT130G1-4035	3	460	3.5	5
VT130G1-2055	5	230	5.5	16
VT130G1-4055	5	460	5.5	8
ESP130230075	7.5	230	8.0	22.0
ESP130460075	7.5	460	8.0	11.0
ESP130230100	10.0	230	11.0	30.0
ESP130460100	10.0	460	11.0	15.0
ESP130230150	15.0	230	16.0	45.0
ESP130460150	15.0	460	16.0	22.0
ESP130230200	20.0	230	22.0	60.0
ESP130460200	20.0	460	22.0	30.0
ESP130230250	25.0	230	27.0	75.0
ESP130460250	25.0	460	27.0	37.0
ESP130230300	30.0	230	33.0	90.0
ESP130460300	30.0	460	33.0	45.0
ESP130230400	40.0	230	40.0	108.0
ESP130460400	40.0	460	40.0	54.0
ESP130230500	50.0	230	50.0	140.0
ESP130460500	50.0	460	50.0	70.0
ESP130230600	60.0	230	60.0	170.0
ESP130460600	60.0	460	60.0	85.0
ESP130460750	75.0	460	75.0	100.0
ESP130461000	100.0	460	104.0	140.0

Verbal Price
Ty Patrick
$2185 FOB Calgary
+ Tax

Ambient Operating Temperature: 0° to 40°C
Storage Temperature: −25° to 70°C
Relative Humidity: Max 90% RH, No Condensation
Vibration: Less Than 0.5G
Height Above Sea Level: Up to 3300 ft.

STANDARD FEATURES

3/4-5 HP RATINGS VT 130G1 SERIES		7.5-100 HP RATINGS ESP SERIES
30, 50/60 Hz, ±2 Hz, 230/460 VAC (¾HP, 230V)	Input Voltage	30, 50/60 Hz, ±2 Hz, 230*/460**VAC
Recommend Customer Supplied Outside Std. Enclosure Recommend Customer Supplied Outside Std. Enclosure Recommend Customer Supplied Outside Std. Enclosure Recommend Customer Supplied Outside Std. Enclosure Recommend Customer Supplied Outside Std. Enclosure	Incoming Circuit Breaker Incoming Main Starting Contactor 30 Input Fuse Protection Surge Suppressor Overcurrent Relay for Motor Protection	Standard Feature Standard Feature Standard Feature Standard Feature Standard Feature
Standard Feature	LED Diagnostic Fault Indicators	Standard Feature
Standard Feature	LED DC Bus Charged Indicator	Standard Feature
Standard Feature	Adjustable V/f Ratio (Low Speed Torque	Standard Feature
Standard Feature	Adjustable Voltage Boost	Standard Feature
1-20 Sec.	Acceleration Rate	6-60 Sec.; G Series[1] 1-20 Sec. or 3-60 Sec.
1-20 Sec.	Deceleration Rate	6-60 Sec.; G Series[1] 1-20 Sec. or 3-60 Sec.
3-80 Hz (6-160 Hz, 12-320 Hz)	Frequency Range	3-90 Hz; G Series 3-80 Hz, 6-160 Hz, 12-320 Hz
	Protect Functions	
Standard Feature 250% IET (trips fault) 0 to 0 (trips fault) High DC Bus Voltage (trips fault) 20% (trips fault) 10 Milliseconds DC Bus Fuse Protection	Current Limit Overcurrent Short Circuit Overcurrent Undervoltage Momentary Power Failure Fusing	Standard Feature 250% IET (trips fault) 0-0 (trips fault) High DC Bus Voltage (trips fault) 20% Low (trips fault) 10 Milliseconds DC Bus Fuse Protection or 30 Input Fusing
1C Relay	Fault Detecting Signal	1C Relay
Run/Stop; Speed Pot (one turn); Frequency Meter (Digital) (LED Fault Readout)	Front Panel Control	Speed Pot (one turn); Frequency Meter (Analog) Illuminated Start and Stop Push Button
NEMA 1	Enclosure	NEMA 1
.5% Maximum Frequency 25°C ± 10°C	Frequency Regulation	.5% Max. Freq. 25°C ± 10°C
Standard Feature	4-20 mA Signal Follower	Standard Feature
Standard Feature	Ramp to Stop (Fault causes Coast Stop)	Standard Feature
Regenerative power is charged back through the DC Bus smoothing capacitor to produce an approximate 12% continuous braking torque. For larger braking torques optional dynamic braking units are available.	Regeneration	Regeneration power is charged back through the DC Bus smoothing capacitor to produce an approximate 12% continuous braking torque. For larger braking torques optional braking units are available.

*208 VAC with field modification
**400 VAC with field modification
[1] G Series: Check your local supplier or Toshiba for available ratings.

TOSHIBA/HOUSTON
INTERNATIONAL CORPORATION

ESP-130 SERIES

ADJUSTABLE SPEED DRIVE GENERAL PURPOSE TRANSISTORIZED INVERTER

ENCLOSURES

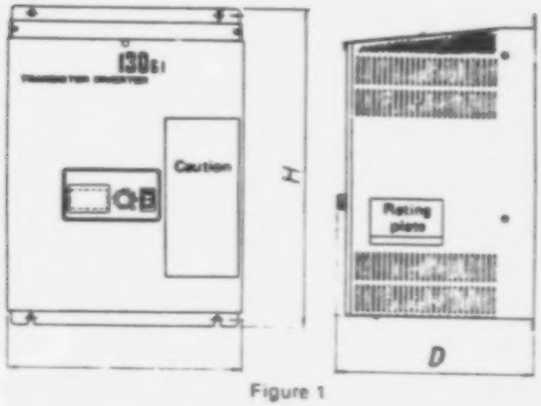


Figure 1

Wall type

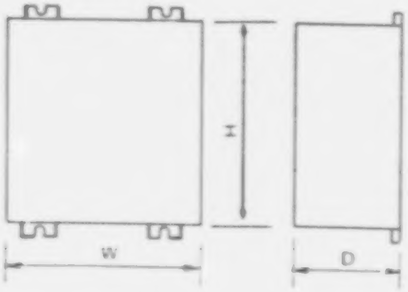


Figure 2

(Weights and Dimensions
May Change
Due to Options)

RATING (HP)	TYPE ENCLOSURE	WEIGHT (APPROX) KG	WEIGHT (APPROX) LBS	MM H x W x D	INCHES H x W x D
¾ (230V)	1	6	13	310 × 246 × 196	12.2 × 9.7 × 7.7
¾ (230V)	12	46	125	915 × 508 × 254	36 × 24 × 10
1 (230V)	1	6	13	310 × 246 × 196	12.2 × 9.7 × 7.7
1 (460V)	1	8	18	350 × 246 × 215	13.8 × 9.7 × 8.5
1 (BOTH)	12	46	125	915 × 508 × 254	36 × 24 × 10
2 (230V)	1	6	13	310 × 246 × 196	12.2 × 9.7 × 7.7
2 (460V)	1	8	18	350 × 246 × 215	13.8 × 9.7 × 8.5
2 (BOTH)	12	46	125	915 × 508 × 254	36 × 24 × 10
3 (BOTH)	1	8	18	350 × 246 × 215	13.8 × 9.7 × 8.5
3 (BOTH)	12	75	125	915 × 508 × 254	36 × 24 × 10
5 (BOTH)	1	9	20	350 × 246 × 215	13.8 × 9.7 × 8.5
5 (BOTH)	12	75	165	915 × 762 × 254	36 × 30 × 10
7.5	1	122	269	1219 x 610 x 305	48 x 24 x 12
7.5	12	125	276	1219 x 914 x 508	48 x 36 x 20
10	1	123	271	1219 x 610 x 305	48 x 24 x 12
10	12	143	315	1524 x 914 x 508	60 x 36 x 16
15	1	127	280	1219 x 610 x 305	48 x 24 x 12
15	12	166	366	2287 x 610 x 508	90 x 36 x 20*
20	1	197	434	1524 x 610 x 305	48 x 36 x 12*
20	12	261	574	1524 x 914 x 508	60 x 36 x 20*
25	1	200	439	1524 x 914 x 305	48 x 36 x 12
25	12	263	579	1524 x 914 x 508	60 x 36 x 20*
30	1	245	540	1524 x 914 x 305	48 x 36 x 12
30	12	309	680	1524 x 914 x 508	60 x 36 x 20*
40(230V)	1	245	540	1524 x 914 x 305	60 x 36 x 12
40(460V)	1 & 12	309	680	1524 x 914 x 508	60 x 36 x 20*
50(230V)	1	423	930	2287 x 610 x 508	90 x 36 x 20*
50(230V)	12	486	1070	2287 x 610 x 508	90 x 36 x 20*
50(460V)	1	248	545	1524 x 914 x 508	60 x 36 x 20
50(460V)	12	311	685	1524 x 914 x 508	60 x 36 x 20*
60	1	478	1051	2287 x 610 x 508*	90 x 36 x 20*
60	12	541	1191	2287 x 610 x 508*	90 x 36 x 20*
75	1	478	1051	2287 x 610 x 508*	90 x 36 x 20*
75	12	541	1191	2287 x 610 x 508*	90 x 36 x 20*
100	1	478	1051	2287 x 610 x 508*	90 x 36 x 20*
100	12	541	1191	2287 x 610 x 508*	90 x 36 x 20*

For 20 HP and above all Type 12 Enclosures include a side mounted air conditioner (right hand side as looking at front panel). Allow an extra 12 inches (305 mm) clearance to the width of these models. *Floor Mounting Only. All Data Subject to Change Without Notice. Consult Factory for Type 4 Enclosures.

AVAILABLE OPTIONS

- **Enclosures:** Standard NEMA 4 and NEMA 12 enclosures may be specified (see previous page for dimensions). Mounting feet for all enclosures except NEMA 1 enclosures on the 1 thru 5 HP models are available.
- **Isolation Transformers:** For added equipment protection, added personnel protection and lightning protection isolation transformers are available in 230V/230V, 460V/460V, and 460V/230V models and mounted in separate NEMA 1 enclosures. Autotransformers are also available in 460V/230V and 230V/460V models.
- **Special 1-5 HP Packaging:** Includes a NEMA 12 enclosure, circuit breaker, input starting contactor, overcurrent relay, and operator's devices mounted on enclosure door. A modified NEMA 1 enclosure is also available.
- **By-Pass Operation:** Allows the user to switch the motor from the speed control of the inverter to across the line and vice versa. A switch and two additional contactors are provided to achieve this. For by-pass operation on the 1-5 HP units, special 1-5 HP packaging must also be ordered.
- **Speed Signal Follower:** The inverter speed can be controlled from an external signal source such as pressure sensors, flow meters, thermocouple, etc. which output a 0-10VDC signal or 4-20 mA DC signal to input into the inverter. When external speed signal sources are used the speed control pot supplied with the inverter must be disconnected.
- **Transducer:** A separate 3-15 psi transducer is available to convert pressure into an electrical signal (4-20 mA) to control the speed of the inverter.

ISOLATION TRANSFORMER RECOMMENDATIONS

HP	kVA	Weight (APPROX) LB	MM H x W x D	IN H x W x D
1.0	1.6	65	406 x 406 x 356	16 x 16 x 14
2.0	2.8	90	406 x 406 x 356	16 x 16 x 14
3.0	3.6	100	406 x 406 x 356	16 x 16 x 14
5.0	6.0	144	508 x 559 x 356	20 x 22 x 14
7.5	9.0	188	508 x 559 x 356	20 x 22 x 14
10.0	12.0	208	508 x 559 x 356	20 x 22 x 14
15.0	18.0	268	508 x 559 x 356	20 x 22 x 14
20.0	24.0	285	508 x 559 x 356	20 x 22 x 14
25.0	30.0	373	610 x 610 x 406	24 x 24 x 16
30.0	34.0	402	610 x 610 x 406	24 x 24 x 16
40.0	43.0	435	610 x 610 x 406	24 x 24 x 16
50.0	56.0	554	711 x 711 x 508	28 x 28 x 20
60.0	67.0	624	711 x 711 x 508	28 x 28 x 20
75.0	80.0	Contact Factory		
100.0	110.0			

ESP-130 SERIES

ADJUSTABLE SPEED DRIVE GENERAL PURPOSE TRANSISTORIZED INVERTER

AVAILABLE OPTIONS

- **Manual/Auto Selections:** Speed control of the inverter can be alternated between the speed pot supplied with the drive and an external speed control source. Any change in speed resulting from the switch causes the inverter to follow the accel/decel rate to attain the new selected speed. A relay is used to disconnect whichever signal is not desired and connect the desired signal source.
- **Multiple Speed Selection:** Any number of speed control pots may be used for multiple speed selection. Miniature relays are used to select which speed pot determines the output frequency. The standard drive comes with one speed control potentiometer. Additional speed control selection units are available.
- **Ten turn Speed Control Pot:** A ten turn speed potentiometer may be substituted for the standard one turn speed potentiometer allowing for easier operator regulation of speed selection.
- **Forward/Reverse Operation:** Forward/Reverse operation is performed electronically and performed by a selector switch which either signals the forward or reverse signal to the microprocessor. When going from forward to reverse or vice versa, the output follows the decel rate to zero and then follows the accel rate.
- **Jogging:** Jogging operation is available and determined by jog time and accel or decel rates selected.
- **Fault Light Indicator:** Fault LED indicators are standard on the PC board of the inverters. An optional fault pilot light with amber lens and legend plate reading "Fault" displays when a fault condition exists (under/overcurrent, overvoltage, overheat (drive), and thermal overload condition of the motors. If desired for 1-5 HP models special 1-5 HP packaging must be specified.
- **Voltage Feedback Control:** For applications requiring highly stabilized constant-torque characteristics especially in the low speed range a voltage control feedback circuit is available on the 15 HP-100 HP S-Series models.
- **Tach Feedback Control Circuitry:** For applications requiring extremely accurate speed regulation which take into account motor slip, the inverter speed may be regulated by a tach feedback signal through the inverter. The tachometer is not furnished in this option and should be a single phase, 24 P, 24 VAC at motor maximum RPM.
- **Max/Min Frequency Settings:** Constant frequency operation or limited operating frequency range is available through use of PC board adjustments or speed pot additions. (This is a standard feature on G Series units.)
- **Additional Contacts:** Additional contacts, NO or NC, can be supplied to terminal blocks for customer's use. (If this option is specified on the 1-5 HP unit, special 1-5 HP packaging must also be specified.)
- **Space Heaters:** For areas with high relative humidity or with extreme cold conditions, space heaters with thermostats are recommended to prevent condensation or to keep the enclosure temperature stable.
- **Special Meters:** The ESP-130 series come with a standard analog frequency meter. Optional meters include: digital frequency meter, analog or digital ammeter (0-1 mA DC); analog or digital voltmeter which measure the A-B phase, three phase current output or input, three phase voltage output or input; wattmeters, and elapsed time meters can also be provided.
- **Remote Station:** Remote stations can contain any combination of operator devices. The standard remote station (NEMA 12 enclosure) contains an analog frequency meter, a single turn speed pot, and a run/stop selector.
- **Local/Remote Operation:** For applications when remote or local control (controls on the power unit) is required. (When specified for 1-5 HP models, special 1-5 packaging must also be specified.)
- **Dynamic Braking:** For applications requiring frequent quick deceleration and stopping or applications with a high inertia load, a dynamic brake unit may be required to absorb the regenerative energy of the motor (in excess of the 12% continuous). Standard 20% duty cycle and 100% duty cycle dynamic braking units are available.

TOSHIBA/HOUSTON
INTERNATIONAL CORPORATION

ESP-130 SERIES

ADJUSTABLE SPEED DRIVE · GENERAL PURPOSE TRANSISTORIZED INVERTER

EFFECTIVE MAY 1, 1984

MODEL #	HP	VOLTAGE	KVA	CONSTANT TORQUE RATED CURRENT (A)	LIST PRICE
VT130G1-2010	3/4	208/230	1.0	4.0	$ 624
VT130G1-2015	1	208/230	1.5	5.0	780
VT130G1-2025	2	208/230	2.5	7.0	942
VT130G1-2035	3	208/230	3.5	9.0	1032
VT130G1-2055	5	208/230	5.5	15.0	1280
VTG130230075	7 1/2	208/230	8.0	22	$ 1934
ESP130230075	7 1/2	208/230	8.0	22	2929
VTG130230100	10	208/230	11.0	30	3151
ESP130230100	10	208/230	11.0	30	4148
VTG130230150	15	208/230	16.0	45	3876
ESP130230150	15	208/230	16.0	45	4899
VTG130230200	20	208/230	22.0	60	5314
ESP130230200	20	208/230	22.0	60	6165
VTG130230250	25	208/230	27.0	75	6063
ESP130230250	25	208/230	27.0	75	6693
VTG130230300	30	208/230	33.0	90	6581
ESP130230300	30	208/230	33.0	90	7817
VTG130230400	40	208/230	40.0	108	7178
ESP130230400	40	208/230	40.0	108	8308
ESP130230500	50	208/230	50.0	140	10225
ESP130230600	60	208/230	60.0	170	10658
VT130G1-4015	1	460	1.5	2.3	$ 1067
VT130G1-4025	2	460	2.5	3.5	1277
VT130G1-4035	3	460	3.5	4.5	1400
VT130G1-4055	5	460	5.0	7.5	1750
VTG130460075	7 1/2	460	8.0	11	$ 2363
ESP130460075	7 1/2	460	8.0	11	3340
VTG130460100	10	460	11.0	15	3245
ESP130460100	10	460	11.0	15	4225
VTG130460150	15	460	16.0	23	4245
ESP130460150	15	460	16.0	23	5344
VTG130460200	20	460	22.0	30	5783
ESP130460200	20	460	22.0	30	6847
VTG130460250	25	460	27.0	37	$ 7283
ESP130460250	25	460	27.0	37	8350
VTG130460300	30	460	33.0	45	8928
ESP130460300	30	460	33.0	45	10200
ESP130460400	40	460	40.0	54	11022
ESP130460500	50	460	50.0	70	12333
ESP130460600	60	460	60.0	90	14195
ESP130460750	75	460	75.0	100	16032
ESP130461000	100	460	104.0	140	21710

NOTE: ESP prefix model is with NEMA 1 enclosure, incoming circuit breaker, incoming contactor, and overload relay.

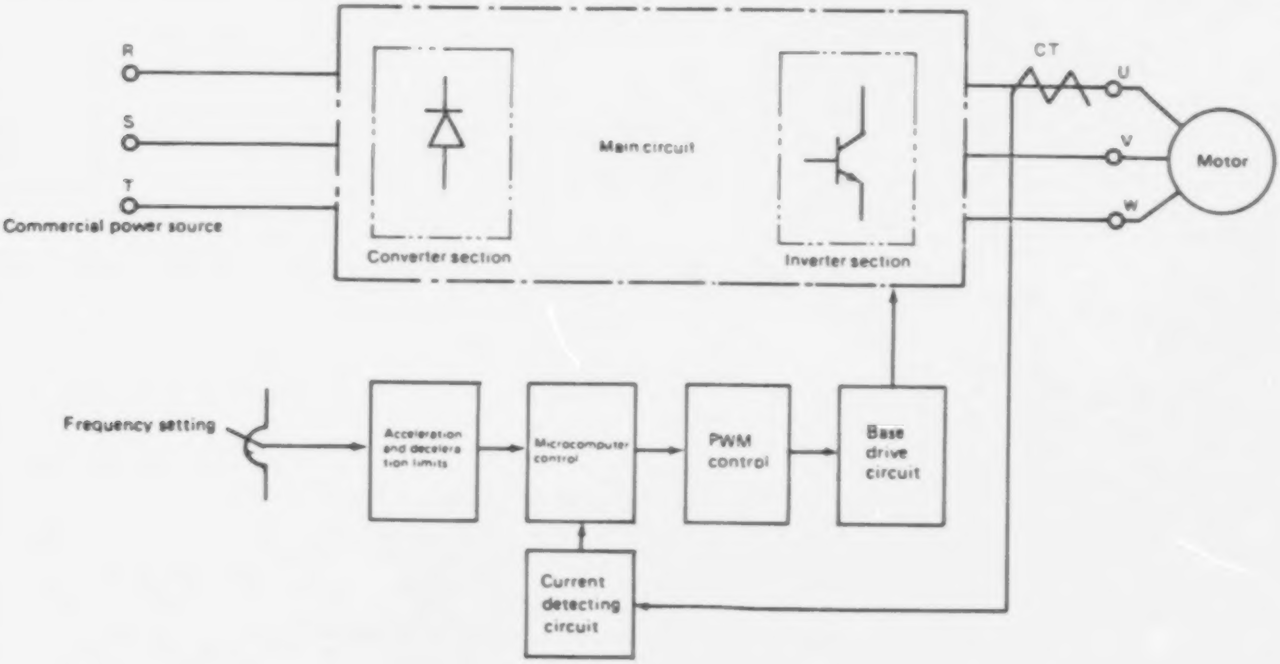
VT prefix is power unit only including top and bottom covers.

USEFUL INFORMATION WHEN ORDERING

Application ______________________________ Type Load ☐ Constant Torque ☐ Constant HP ☐ Variable Torque
__________ HP
Speed/Frequency Range ______________
Starting Torque Required ______________
Acceleration Time Required ______________
Enclosure ______________
Power Supply 3Ø ________ V
Mechanical Reduction Drive Used? ______________
Accelerating Torque Required ______________
Deacceleration Time Required ______________

AC Motor Information ☐ New ☐ Existing
Frame Size __________ HP __________ Service Factor __________
RPM __________ Volts __________ Hz __________ Class Insulation __________
Required Options

Circuit Configuration (7.5 HP and above)


R
S
T
Commercial power source
Converter section
Main circuit
Inverter section
CT
U
V
W
Motor
Frequency setting
Acceleration and deceleration limits
Microcomputer control
PWM control
Base drive circuit
Current detecting circuit

APPENDIX 5

Torque Sensor Data

TELEDYNE
ENGINEERING SERVICES

POST OFFICE BOX 288

MARION, MA 02738

(617) 748-0103

December 10, 1984
8414-288

Mr. Al Hoar
Cambrain Engineering
4815 78th Avenue Southeast
Calgary, Alberta
Canada T2C Y9

Subject: Torque Sensors

Reference: Telecon - Mr. A. Hoar/Mr. R. Masson - December 6, 1984

Dear Mr. Hoar:

Enclosed is a "Torque Sensors" catalog which Mr. Roger W. Masson asked me to forward in response to your request for literature.

Please do not hesitate to contact Mr. Masson if we can be of further assistance.

Yours truly,

TELEDYNE ENGINEERING SERVICES

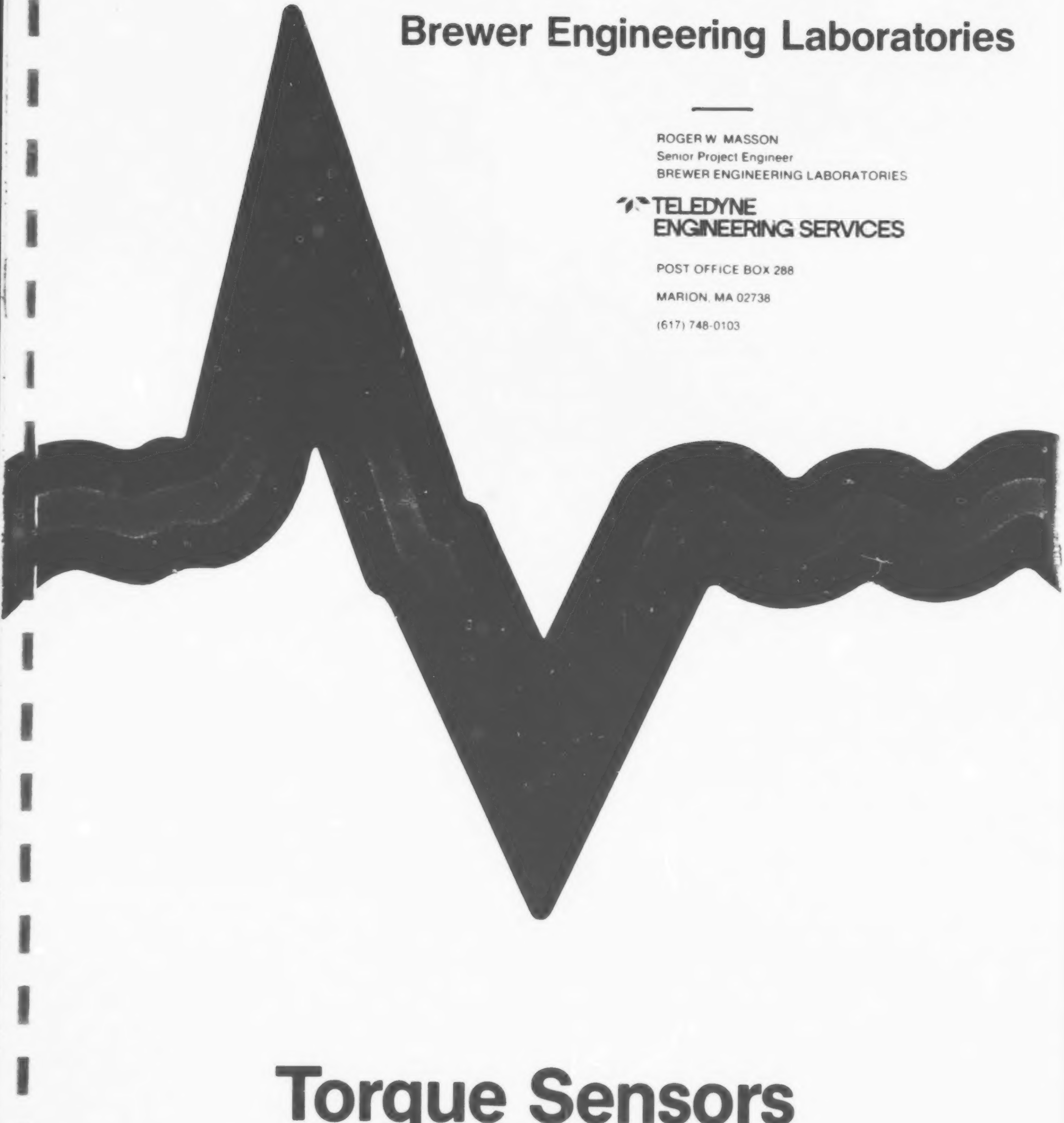
Diane Drake

Mrs. Diane Drake, Engineering Assistant
Brewer Engineering Laboratories

DD:s
Enclosure
c.c. Mr. R. W. Masson

BREWER ENGINEERING LABORATORIES

Brewer Engineering Laboratories



ROGER W. MASSON
Senior Project Engineer
BREWER ENGINEERING LABORATORIES

TELEDYNE
ENGINEERING SERVICES

POST OFFICE BOX 288

MARION, MA 02738

(617) 748-0103

Torque Sensors

Torque Sensors . . .

BREWER ENGINEERING LABORATORIES, INC.
MARION, MASSACHUSETTS
TYPE
SERIAL NO.

Features:

- Complete unit . . . integral torque sensing shaft with bearings and brush assembly
- Easy to install
- Excellent for temporary measurement set ups
- 350-ohm strain gage bridge
- Accurate to 0.25% of rated output
- Capacity 10-inch-pounds to 30,000 inch-pounds

The Ultimate in Bonded Strain Gage Torque Measurement Transducers

Introduction . . .

BEL Torque Sensors are electronic transducers which produce an electrical signal proportional to an applied torque while in no way changing the speed or torque.

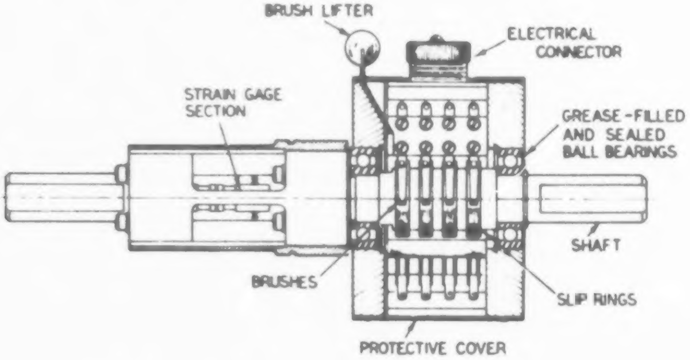
The BEL Torque Sensor is essentially a short length of shaft which, when loaded in torsion, translates that torsion into changes in electrical output. Thus, when coupled into a line of shafting, the pickup will measure the torque being transmitted by that shaft while in no way influencing or changing its magnitude. This measurement is also independent of speed.

The torque-sensitive element in each BEL Torque Sensor is a modification of the well-known bonded resistance strain gage in which any change in strain produces a corresponding change in resistance of the gage. The strain gages are bonded to the shaft in such a position, and are so connected into a Wheatstone bridge circuit, as to cancel the effects of bending and thrust strains while adding the effects of torsional strains. The relation between bridge unbalance and torsional strain is linear.

Slip rings on the shaft, and a non-rotating brush assembly, allow the strain gage bridge to be energized and its resistive unbalance measured by a suitable readout instrument.

Measurement of torque in this manner offers unlimited application opportunities. Among the many services now being performed by Torque Sensors are such tasks as engine, compressor, pump, and motor testing, as well as hundreds of other applications in both design and production involving torque or power measurements.

High on the list of assets is the inherent accuracy of these transducers as noted in the table of dynamic characteristics. Ease of handling and simplicity of operation permit application of BEL Torque Sensors in practically every field requiring accurate torque measurements.



General

The Type A Torque Sensor is a self-contained unit in which the brush assembly is mounted on the torque shaft by ball bearings. Ease of installation makes it the ideal unit for use where set-up is to be made frequently by untrained personel. Type A Torque Sensors are available in 11 standard capacities from 10 inch-pounds to 30,000 inch-pounds. All are furnished with a 15-foot connector-ended cable as standard equipment. Special connectors or cables are available on order at slight additional cost. Full scale output is 1.500 millivolts per volt input on standard capacity pickups. A brush lifting device is provided to eliminate brush wear when torque readings are not required.

Temperature Limits
Maximum temperature limit for continuous operation is 140°F for the Type A Sensor. This limit is fixed by allowable bearing temperature. Water cooling of bearings is provided for in capacities of 12,000 inch-pounds and 30,000 inch-pounds.

Speed Limit
Operating speed of Type A Sensors is limited by permissible bearing speeds. All Torque Sensor bearings will operate for short times at speeds above their ratings. If a Type A Sensor must be operated above its rating, spare bearings should be kept on hand as replacements when original bearings become noisy or overheat badly. Damage to the pickup can result if bearings seize during a run.

Magnetic Fields
When operating the pickup and/or the readout instrument in very strong magnetic fields, consult the factory.

Bending Stresses
The strain gages are so oriented and connected that the torque shaft response to bending is negligible. However, bending stresses (which might be caused by misalignment of machines or bearings), when added to the high torsional stress in the measuring section of the shaft, could approach the fatigue limit of the steel. Therefore, flexible couplings should almost always be used for mounting the torque pickup.

Flexible couplings are not necessary if very close torque shaft alignment can be established and maintained during operation.

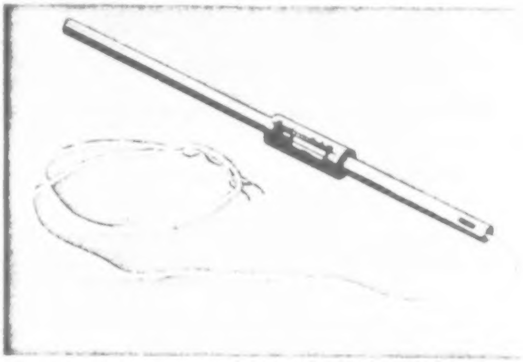
Torsional Impact
It should be recognized that it is possible to apply large torques to the pickup by sudden changes of load or speed or by operating at, or going through, a critical speed. Specified overload characteristics apply in the case of impact loading also, as long as the peak of the torsional impact does not exceed the rated overload torque capacity.

Oscillating Torque
A peak-to-peak amplitude of 30% of the average torque will not damage the pickup provided the maximum torque reached is within the rated static torque capacity.

Options

0-5 VDC Output
An internal electronic amplifier is available as an option to provide a ±5 VDC output signal. BCD output is also optional. Consult BEL for further details.

Special Torque Sensors
The Type A Torque Sensor is a general purpose transducer. For situations where another design may be more appropriate, BEL will design and build a torque sensor to a customer's specification. These sensors may be rotating or nonrotating, use slip rings or radio telemetry, or have special geometries to fit available space. Please contact BEL with your specifications for a technical and financial proposal.



A typical nonrotating Torque Sensor is shown above. This semiconductor strain gage Torque Sensor is used in flight simulators. The unit provides a control signal to the feedback servomechanisms that provide the simulator pilot with the same control loads encountered in flying the airplane. Units are machined from stainless steel and are protected against extremes of temperature and humidity.

Typical Specifications

Load Range	±300 In-Lbs
Temperature Range	70°F to 120°F
Output	100 mv/v
Size	1/2" Outside Diameter (Shaft) x 7/8" Diameter (Shield) x 10" - 16" Long

Specifications

Type A Torque Sensors

Capacities

10 20 50 100 200 500 1,000 2,000 5,000 12,000 and 30,000 in -lb

Performance

Output at rated torque (R T) 1 5mv/V
Calibration accuracy .... 0 25% R T CW or CCW
Nonlinearity
  10-50 in -lb .... 0 10% R T
  all others .... 0 05% R T
Repeatability .... 0 05% R T
Hysteresis
  10-50 in -lb .... 0 15% R T
  all others .... 0 05% R T

Temperature

Temperature range safe .... −50 to 140°F
compensated ... 0 to 140°F
Temp effect on Rated Torque .... 0 005% Reading per °F
Temp effect on Zero Balance .... 0 0025% R T per °F

Electrical

Excitation recommended .... 12 V AC or DC
maximum .... 25 V AC or DC
Zero balance @ 72 ±3°F............. 2 5% R T
Terminal resistance input .... 350 ±1 5 ohms
output .... 350 ±3 ohms

Termination

MS3102A-18-8S-A105 connector with mating 15-ft cable assembly

Insulation resistance
  bridge to ground .... 2,000 megohms
  shield to ground .... 1,000 megohms

Overload Ratings

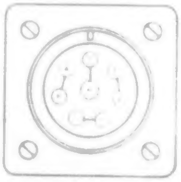
Safe................................. 120%
Electrical failure 300%

Dynamic Characteristics
Type A

TORQUE PICKUP TYPE	CAPACITY IN. - LB.	MAX. SPEED R.P.M.	WR^2 LB. - IN.^{2}	FLEXURAL NATURAL FREQUENCY R.P.M.	TORSIONAL STIFFNESS IN. - LB./RADIAN	WEIGHT LB.
A-001	10	3,600	634	15,500	300	3
A-002	20	3,600	636	17,500	900	3
A-005	50	3,600	643	23,000	2,300	3
A-01	100	7,000	1 26	46,600	14,800	5 5
A-02	200	7,000	1 26	46,600	14,800	5 5
A-05	500	7,000	1 32	81,800	79,700	6
A-1	1,000	7,000	1 56	86,600	72,600	6
A-2	2,000	5,000	2 69	29,200	99,300	17
A-5	5,000	5,000	2 78	31,800	238,000	17 5
A-12	12,000	5,000 ①	22 6	37,400	905,000	39
A-30	30,000	5,000 ①	23 5	41,600	1,680,000	42

NOTE: The tabulated data pertains to the torque pickup only and does not include the effects of couplings or other rotating masses that would be part of a dynamic system

① For speeds above 3,000 R P M water cooling should be used Water inlet and outlet provided

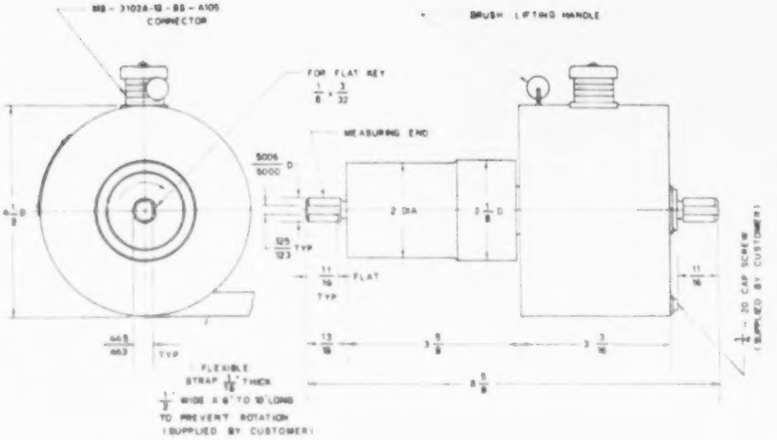


Connector Wiring
MS3102A-18-8S-A105

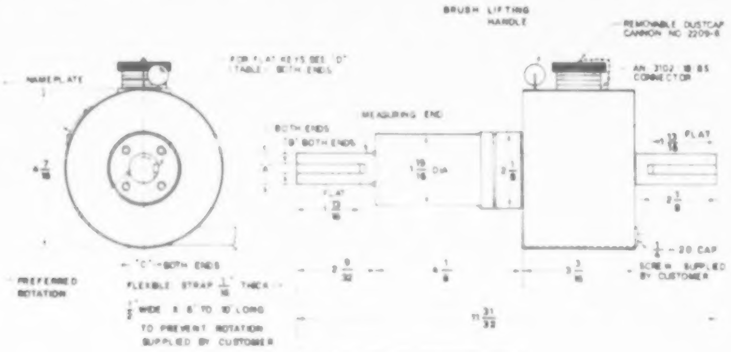
INPUT	AB—Green EF—Black	OUTPUT	CD—Red GH—White

Dimensional Drawings
Type A Torque Sensors

10, 20, & 50 IN.-LB.

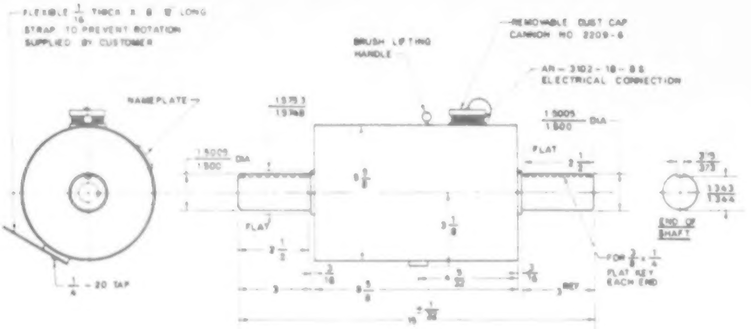

MS - 3102A - 10 - 8S - A105 CONNECTOR
BRUSH LIFTING HANDLE
FOR FLAT KEY $\frac{1}{8} \times \frac{3}{32}$
MEASURING END
$\frac{.5005}{.5000}$ D
$4\frac{1}{2}$ D
2 DIA
$2\frac{1}{8}$ D
$\frac{.125}{.123}$ TYP
$\frac{11}{16}$ FLAT TYP
$\frac{11}{16}$
$\frac{.445}{.443}$ TYP
$\frac{13}{16}$
$3\frac{5}{8}$
$3\frac{3}{16}$
$8\frac{5}{8}$
$\frac{1}{4}$ - 20 CAP SCREW (SUPPLIED BY CUSTOMER)
FLEXIBLE STRAP $\frac{1}{16}$" THICK $\frac{1}{2}$" WIDE X 6" TO 10" LONG TO PREVENT ROTATION (SUPPLIED BY CUSTOMER)

100, 200, 500 & 1,000 IN.-LB.

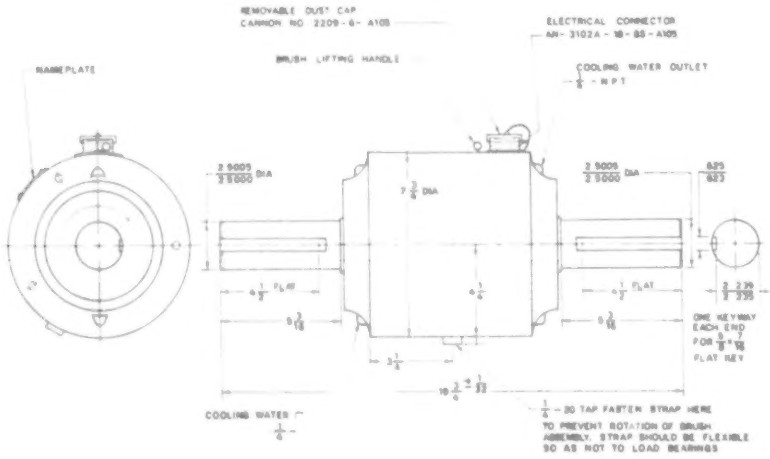

BRUSH LIFTING HANDLE
REMOVABLE DUSTCAP CANNON NO. 2209-8
AN 3102 - 18 - 8S CONNECTOR
NAMEPLATE
FOR FLAT KEYS SEE "D" TABLE - BOTH ENDS
MEASURING END
BOTH ENDS
"B" BOTH ENDS
A
$4\frac{7}{16}$
$1\frac{15}{16}$ DIA
$2\frac{1}{8}$
$1\frac{13}{16}$ FLAT
FLAT $1\frac{13}{16}$
$2\frac{1}{8}$
"C" BOTH ENDS
PREFERRED ROTATION
FLEXIBLE STRAP $\frac{1}{16}$" THICK $\frac{1}{2}$" WIDE X 6" TO 10" LONG TO PREVENT ROTATION SUPPLIED BY CUSTOMER
$2\frac{9}{32}$
$4\frac{1}{8}$
$3\frac{3}{16}$
$\frac{1}{4}$ - 20 CAP SCREW SUPPLIED BY CUSTOMER
$11\frac{31}{32}$

CAPACITY	A	B	C	D
A-01 A-02	$\frac{.5006}{.5000}$	$\frac{.125}{.123}$	$\frac{.445}{.443}$	$\frac{1}{8} \times \frac{3}{32}$
A-05 A-1	$\frac{.8753}{.8749}$	$\frac{.1875}{.1865}$	$\frac{.802}{.800}$	$\frac{3}{16} \times \frac{1}{8}$

2,000 & 5,000 IN.-LB.


FLEXIBLE $\frac{1}{16}$ THICK X 8 - 12 LONG STRAP TO PREVENT ROTATION SUPPLIED BY CUSTOMER
BRUSH LIFTING HANDLE
REMOVABLE DUST CAP CANNON NO. 2209-8
AN - 3102 - 18 - 8S ELECTRICAL CONNECTION
NAMEPLATE
$\frac{1.3753}{1.3748}$
$\frac{1.5005}{1.500}$ DIA
$\frac{1.5005}{1.500}$ DIA
FLAT
$2\frac{1}{2}$
$\frac{.375}{.373}$
$\frac{1.343}{1.344}$
END OF SHAFT
FLAT
$2\frac{1}{2}$
$3\frac{1}{8}$
$\frac{3}{16}$
$4\frac{5}{32}$
$\frac{3}{16}$
FOR $\frac{3}{8} \times \frac{1}{4}$ FLAT KEY EACH END
$\frac{1}{4}$ - 20 TAP
3
$8\frac{5}{8}$
3 REF
$15\frac{\pm 1}{32}$

12,000 & 30,000 IN.-LB.


REMOVABLE DUST CAP CANNON NO. 2209 - 8 - A105
ELECTRICAL CONNECTOR AN - 3102A - 18 - 8S - A105
BRUSH LIFTING HANDLE
COOLING WATER OUTLET $\frac{1}{8}$ - NPT
NAMEPLATE
$\frac{2.5005}{2.5000}$ DIA
$7\frac{3}{4}$ DIA
$\frac{2.5005}{2.5000}$ DIA
$\frac{.625}{.623}$
$4\frac{1}{2}$ FLAT
$4\frac{1}{2}$ FLAT
$\frac{2.239}{2.235}$
$6\frac{3}{16}$
$6\frac{1}{4}$
$6\frac{3}{16}$
ONE KEYWAY EACH END FOR $\frac{5}{8} \times \frac{7}{16}$ FLAT KEY
$3\frac{1}{4}$
$19\frac{3}{4} \pm \frac{1}{32}$
COOLING WATER $\frac{1}{8}$
$\frac{1}{4}$ - 20 TAP FASTEN STRAP HERE TO PREVENT ROTATION OF BRUSH ASSEMBLY. STRAP SHOULD BE FLEXIBLE SO AS NOT TO LOAD BEARINGS

Other BEL Services.

Complete engineering studies include:

—Materials properties and product design testing.

—Theoretical and experimental stress analysis.

—Static, dynamic, and vibratory testing.

—Certification of equipment or structure integrity.

—Troubleshooting machinery or equipment malfunctions.

—Laboratory model testing.

—Special transducer design and development.

—Design of laboratory test fixtures and loading mechanisms.

—Formal engineering report preparation.

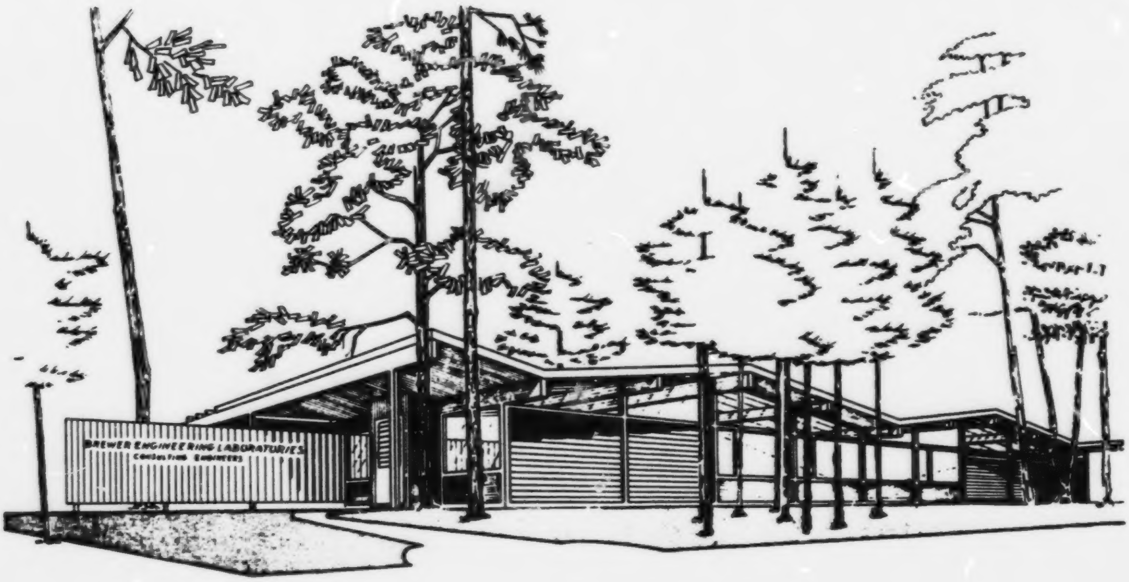
BEL Quality Assurance.

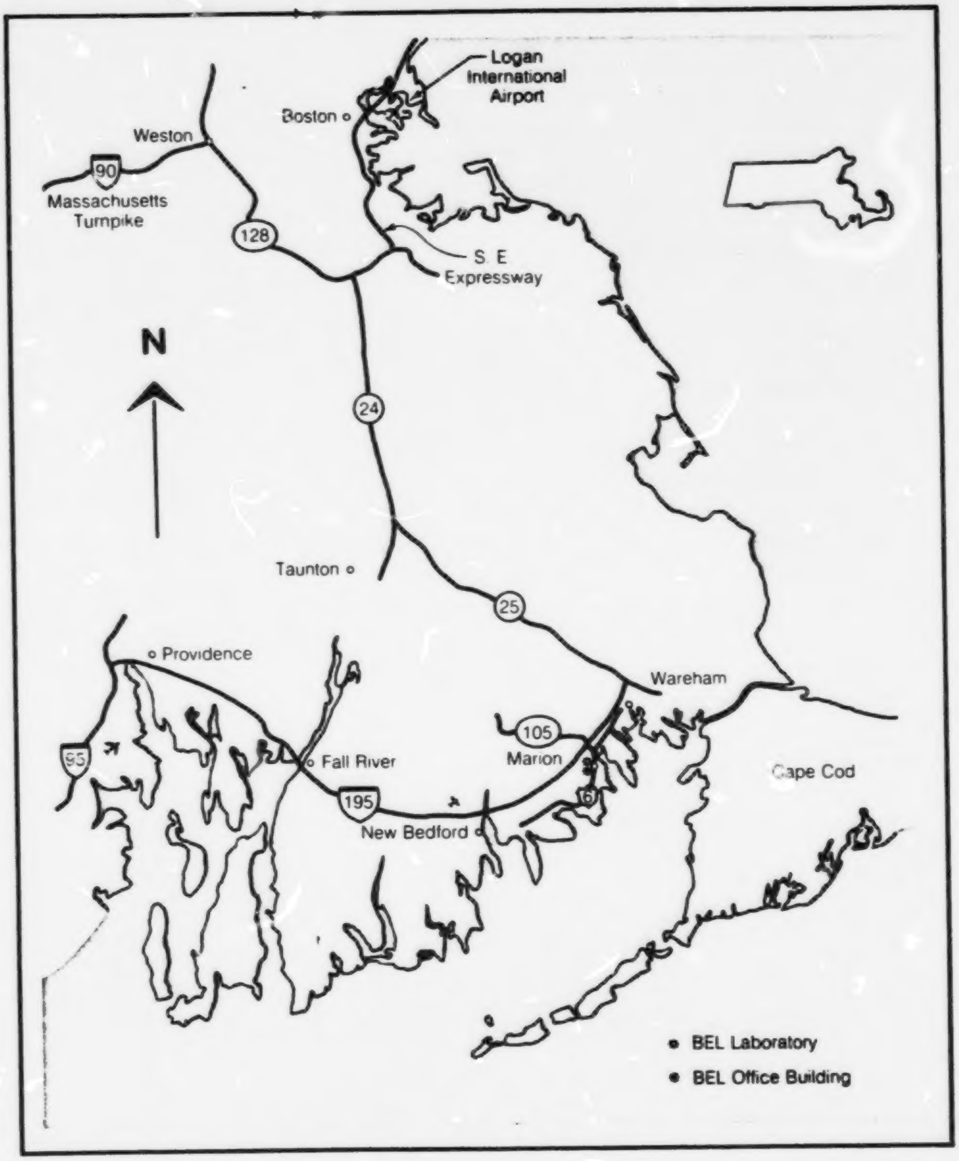
Brewer Engineering Laboratories, Inc., has developed standard procedures for the care, maintenance, installation, and calibration of the instrumentation and specific instruments utilized in all of the test programs undertaken. The BEL Quality Assurance Manual has been prepared to document these procedures and provide calibration data traceable to NBS.

A comprehensive Quality Assurance Plan is prepared for each project in order that the objectives of the particular test specifications are met.

BEL Facilities.

BEL maintains a complete laboratory for strain gage testing, materials properties testing, and transducer manufacturing. A large inventory of portable field test equipment, valued at $1,000,000, is also maintained for experimental stress analysis projects.




Logan International Airport
Boston
Weston
90
Massachusetts Turnpike
128
S. E. Expressway
N
24
Taunton
25
Providence
Wareham
105
Marion
95
Fall River
195
6
New Bedford
Cape Cod
● BEL Laboratory
● BEL Office Building

Brewer Engineering Laboratories, Incorporated

Post Office Box 288
513 Mill Street
Marion, Massachusetts 02738, U.S.A.
Telephone (617) 748-0103

Printed in U.S.A. 9/80

APPENDIX 6

MICON Budget Quote

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

Head Office
1916 - 27 Ave. N.E.
Calgary, Alberta
T2E 7A5
Tel: (403) 230-1581
Tlx: 038-21588

December 7, 1984

Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T2C 2Y9

Attention: Al Hoar

Re: Request for Quotation - Project B3333

Dear Al:

In response to your request, we are pleased to submit our quotation for the MICON Distributed Control System as per our discussions.

The proposed system includes 2 MICON P-200 Controllers and 1 CRT System mounted in a custom enclosure. We are also offering one week of programming and start-up assistance at no charge.

Thank you for considering Cantech Controls for your requirements. If you feel it is necessary to further discuss this proposal, please let me know.

Yours truly,
CANTECH CONTROLS

Brian Kukulski

B. R. Kukulski
Application Engineer

BRK:st

encl.

cc Ken Johnson

CANTECH

CANTECH CONTROLS DIVISION

CANTECH CORPORATION

Head Office
1916 - 27 Ave. N.E
Calgary, Alberta
T2E 7A5
Tel: (403) 230-1581
Tlx: 038-21588

TRAINING & SERVICE SUPPORT

1. TRAINING

Training will be provided by Cantech Factory Trained Instructors for Engineers and Operating Personnel.

A. FACTORY TRAINING
Offered in Montreal, Toronto or Calgary, 5 day courses are given. Topics include System Overview, P-200 Configuration, MDC-200 Set-up and System Maintenance. The cost is $600.00 per person (minimum 4 people).

B. ON SITE TRAINING
A factory trained instructor will visit the clients site to conduct customized training at a cost of $3,500.00. Travel, lodging and meals are at clients expense.

The total MICON System is assembled and checked out as a system in Calgary prior to delivery to the customer. We recommend that at this time, key Engineering and Operating Personnel be at this check-out to be familiarized with the equipment.

NOTE: Training is also available at Powell-Process Systems, Inc. Houston, rates available upon request.

2. SERVICE SUPPORT

Cantech maintains a staff of trained Field Service Engineers who are available for providing technical assistance and direction for the installation start-up, testing, inspection, repair and maintenance of apparatus sold by Cantech.

A. TYPES OF ASSISTANCE

(1) System Commissioning and Start-up - is defined as the placing into service and verifying functionality of the MICON MDC-200 Control System and related sub-systems. Included in start-up assistance is any necessary re-configuration of the system to perform to required specifications.

(2) System Maintenance - is defined as the maintenance assistance performed on the MDC-200 Control System and related sub-systems, that has been in operation and accepted by the Buyer.

2. Service Support (continued)

B. SERVICE RATES

Rates quoted below apply within the boundaries of Canada and are subject to change without notice. Billing will be based on rates in effect at the time service is rendered. Travel time and final report preparation is considered working time. Parts and expenses are additional.

Service	Per Man Day
System Maintenance	$450.00
System Commissioning/Start-up	$500.00

Notes:

(1) There will be a minimum charge of 1/2 day's time. Billing will be in 1/2 day increments for time each day at job and/or travelling during normal working hours.

(2) "Regular Time" is 8 hours per day during the normal working hours of 8:00 a.m. to 5:00 p.m. with one hour for lunch, Monday through Friday, except for legal holidays.

(3) "Overtime" includes all time spent working and/or travelling in excess of 8 hours during a normal working day. This overtime to be billed in hourly increments. Overtime on normal work days and Saturdays will be billed at 1-1/2 times the basic daily rates. Overtime on Sundays or legal holidays will be billed at 2 times normal rates.

C. CONTRACT MAINTENANCE

Details and rates are available upon request.

3. EXPENSES

A. TRAVEL

(1) Expenses to be included are from the Cantech office to the customer's plant and return, plus local travel required for each day.

(2) Travel expenses include bus, rail, air and taxi fares, auto rentals, private auto travel at 20¢ per kilometer, toll charges, parking fees, and baggage handling.

(3) Where our assistance representative goes from job to job, rather than returning to his headquarters, an equitable distribution of travel charges will be made.

B. LIVING

(1) Actual expenses for meals, lodging and incidentals.

C. MISCELLANEOUS

(1) Wires and telephone calls as required in connection with the details of the job will be charged.

3. Expenses (continued)

D. When supplying assistance, it may be necessary to dispatch a man from the Cantech Home Office, or from a District Office other than that which normally serves the customer concerned. In this case travelling and living expenses are based upon the point of origin where the man makes his headquarters. The total elapsed number of working days from departure until return to origin will be billed. The same working hours and other conditions will apply.

E. A 10% handling charge will be applied to all costs expenses except that portion covering car mileage.

4. MATERIALS, OTHER CHARGES

Whenever it is necessary to supply material and other charges in connection with service, the following rates will apply:

A. PSI MATERIAL
Process Systems material will be billed at current prices.

B. PURCHASED MATERIAL
Materials purchased and sub-contracted services are to be billed at cost, plus 15% handling charge.

5. TERMS OF PAYMENT

Terms of payment are net thirty (30) days from date of invoice.

6. LIMITATION OF LIABILITY

As our representatives are authorized to act only in consulting capacity and are not authorized nor licensed to operate equipment, all responsibility for operation rests with the Purchaser. Cantech shall not be liable for any losses, claims, labour expenses or damages direct or consequential, resulting directly or indirectly from the assistance performed hereunder or for other consequential loss or damage of any nature arising from any cause. No back charges to us will be honoured without written agreement made prior to supply of the labour and/or materials involved.

7. INSURANCE

The following coverage is maintained:
(1) Cantech carries insurance for protection from claims under the Provincial Workmen's Compensation Acts.

(2) Cantech carries Public Liability of $2,000,000 for personal injury and $2,000,000 for property damage.

8. FACILITIES

It is assumed that the customer will provide adequate office facilities and normal personal conveniences at no charge to Cantech.

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T2C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 1 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27 Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks			F.O.B. Calgary	TERMS 30 DAYS NET **	
ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			POWELL PROCESS SYSTEMS INC. MICON DISTRIBUTED CONTROL SYSTEM		
1	2		MICON P-200 CONTROLLER Model No.: P-200-1: A1 B5 C0 D1 E1 MICON P-200-1 Controller: Interactive 8-loop microprocessor-based controller with an I/O capacity of: 15 High-level Analog Inputs - 0-5 VDC, 0.25-1.25 VDC, 1-5 VDC. Externally powered. 16 Discrete (On/Off) Inputs - 24-48 VDC, 3-5 MA Opto-isolated. Power from MICON. 8 Discrete (On/Off) Outputs - 10-36 VDC. Externally powered. 8 Analog Outputs (Loops) - 0/4-20 MA into 0-800 ohms. Power from MICON. Self contained with intergral line power supply and operator interface. Data links, to connect into MDC-200 color CRT based operator station and to communicate between MICON's are included. Over 90 control functions are programmed into each MICON whether they are used initially or not. FIRMWARE VERSION: "L4A" CIRCUIT BOARD OPTIONS: Memory Transfer/Communication Back-up Board. RS-232 SERIAL COMMUNICATION: Standard PSI data links included in basis MICON P-200. DATE ENTRY PANEL: Integral configuration side panel. POWER SUPPLY: 110 VAC, 60 HZ, 60 WATTS NOTE: Prices are subject to escalation due to circumstances beyond our control.	17,842.00	35,684.00

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES

CALGARY	SARNIA
EDMONTON	HALIFAX
VANCOUVER	MONTREAL
TORONTO	WINNIPEG
	SASKATOON

QUOTATION

TO: Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T2C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 2 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks F.O.B. Calgary TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
2	2		ANALOG TERMINATION PANEL Model No.: ATP-200: A1 B1 CO Analog Termination Panel with field terminals and female cable connector for MICON analog cable. All components are mounted on a heavy duty printed circuit board. The ATP-200 is normally supplied with precision 250 ohm range resistors (R1 & R2) for 4 to 20 MA transmitters and recorders. The Analog Termination Panel also provides individually fused (1/8 amp) power connections for transmitters (transmitter power is not supplied by MICON). Transmitter power supply connection with LED indication and fusing resistor is included. Terminal for Lateral Communication (MICON-to-MICON data link) and for the Keep-Alive detector are on the ATP-200. MICON RANGE RESISTOR VALUE (R-1): Sixteen 250 ohm Resistors BASE-PLATE MOUNTING: Panel mounted on Discrete or other Analog Termination Base-Plate.	688.00	1,376.00

NOTE: Prices are subject to escalation due to circumstances beyond our control.

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY: ______________________
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T2C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 3 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks			F.O.B. Calgary	TERMS 30 DAYS NET **	
ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
3	2		DISCRETE TERMINATION PANEL Model No.: DTP-200: A1 Discrete Termination Panel with field terminals and female cable connectors for MICON discrete cable. All components are mounted on a heavy duty printed circuit board. Terminal board provides individually fused power connections for discrete outputs to drive DC loads (discrete output power for external devices must be supplied separately from MICON). Common power supply connection with LED indications and fusing resistor is included. Female cable connector for optional PSI SSR-200 solid-state relay unit is provided. Relays can be applied to Discrete Inputs or Outputs. Terminals for the Vertical Communication (MICON to-Communicator data link) are on the DTP-200. BASE-PLATE MOUNTING: Panel mounted on Analog or other Discrete Termination Base-Plate. **NOTE:** *Prices are subject to escalation due to circumstances beyond our control.*	619.00	1,238.00

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N E
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T2C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 4 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

/e are pleased to submit the following quotation, subject to
ie terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks
F O B Calgary
TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
4	1		POWER DISTRIBUTION MODULE Model No.: PS-200-8: A1 Redundant Power Supply modules are semi-custom built for PSI by Lambda with an adjustable 26 VDC, 4.0 amps load output at 50 deg. C ambient temperature. Two power supply modules are connected to the PSI Parallel Power Supply Adaptor to provide redundancy. Failure alarms and operation indicators are also provided. Power supply Units are "CSA" Certified. The PS-20-8 provides MICON Systems with: - Transmitter Power Supply - connected to ATP-200 - Capable of handling power for four MICONs - Automatic Transfer System Power - Solid State Relay Logic Power AC POWER: 105-127 VAC, 57-63 HZ	2,591.00	2,591.00

NOTE: Prices are subject to escalation due to circumstances beyond our control.

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T2C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 5 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks
FOB Calgary
TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			SOLID STATE RELAY INTERFACE		
5.1	2		Model No.: SSR-200: A1 Solid State relay modules provides a means of interfacing the Discrete I/O's of the MICON Controller to higher current or voltage output devices or to higher voltage input devices. The OPTO-22 I/O system provides photo-isolated interfaces to MICON P-200. The SSR-200 is mounted on a 19 x 7 inch Termination Base Plate. OPTO 22 Features: - Plug in relay modules - Individual plug-in fuses - Led Status light for individual relay module on-off indication - 2500 VAC isolation The I/O Base Unit requires external 24 VDC power supply. ONE FOOT RIBBON cable with 50-pin cable connectors on both ends for interface between the I/O Base Unit and the MICON P-200 Discrete Termination Panel included.	495.00	990.00
			I/O MODULE		
5.2	32		Model IAC-24AC Input Module. 90 to 140 VAC 10 MA input current.	20.00	640.00
			I/O MODULE		
5.3	16		Model OAC-24 AC Output Module. 12 to 140 VAC 3 amps current rating	20.00	320.00

NOTE: Prices are subject to escalation due to circumstances beyond our control.

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 6 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks
FOB Calgary
TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			CONTROLLER SLIDE TRAY (SHELF) AND CABLES		
6	2		Model No.: CST-200 A1 B1 CO Controller slide tray with accessories for panel mounting. Each MICON Controller fits into its individual shelf. SIGNAL CABLES: Multiconductor cables to connect MICON to the termination panels. 10 ft. long analog and discrete cable set. POWER CABLES: 3-wire, 110 VAC PLUG - 4 ft. long.	877.00	1,754.00
			NOTE: Prices are subject to escalation due to circumstances beyond our control.		

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 7 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks
F.O.B. Calgary
TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			COLOR CRT AND KEYBOARD		
7.1	1		Model No.: CRT-200-1: A3 B2 C1 D1 Microprocessor - based CRT with extensive display capability (Overview, Group, MICON, Loop, Input, Trend, Alarm, etc.). Complete with PSI 96K EPROM board, 32 K of RAM and RS-232C (9600) BAUD serial interface to Intelligent Keyboard. Video Controller is located externally. Each CRT Monitor has a dedicated PSI Keyboard. The Operator Keyboard allows for single-button access to most CRT displays. LED indication to alert the operator of alarm conditions is provided on the Keyboard (In addition to the CRT alarm monitoring). The Z80A based Video Display Control (VDC-200-1) features all application memory for the process and configuration displays, including the interactive graphic firmware. The unit normally provides individual color video (std. red, green and blue with separate sync) output. Composite video is available as a special option. The flexibility of the (VDC-200-1) permits the use of color CRT's from a variety of vendors (Hitachi, Mitsubishi, Aydin, etc.). The Hitachi Terminal is provided as standard. The interface from the VDC-200-1 to Fixed/Removable disk units provides extensive mass storage capability. The Video Display Controller chassis is designed to fit in the lower part of the operator console (std. 19-inch rack design) and normally also houses the disk unit. FIRMWARE VERSION: "E" Series **NOTE:** Prices are subject to escalation due to circumstances beyond our control.	18,818.00	18,818.00

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY: B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 8 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks
F.O.B. Calgary
TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
7.2	1		OPERATOR KEYBOARD: PSI Keyboard with Tactile feedback. INTELLIGENT KEYBOARD: Includes a microprocessor, memory and communication to the video controller (RS-232) and the COMMUNICATOR (PSI data link or RS-232). Second RS-232 link can provide MODEM/FIBER-OPTIC data communicators or allow for optional Operator Keyboard to Host Computer interface. INTERFACE CABLES: Individual Video Cables between VDC-200-1 and CRT. Additionally one three-conductor cable assembly to connect the Video Controller to the Keyboard, and one three-conductor cable to connect the Keyboard to the Communicator. Cable from Keyboard to the Communicator can be up to three miles long. OPTIONAL RS-232 Keyboard - Communicator interface allow for use of Modems or Fiber-optic links. 15 foot Video Controller and Keyboard Cable assemblies and 5 foot Video Cables are included. CRT POWER SUPPLY: 120V, 60 HZ NOTE: Prices are subject to escalation due to circumstances beyond our control.	Incl'd in	7.1

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N E
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO: Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 9 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

e are pleased to submit the following quotation, subject to e terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks F.O.B. Calgary TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			HARD DISK UNIT		
8	1		Model No.: HD-200-1: A1 B1 The disks serve as redundant storage for Operator Station MICON configuration and for user tag numbers/descriptions. The Disk media provides fast system reloading after long-term power outage and off-line configuration changes. The System CRT can share System and Graphic Storage. Disk I/O Controller Board is included and factory installed in the CRT-200. The hard disk unit includes two 5.0 MByte disks, one fixed and one removable. Full interchangability of the removable storage medium is provided. The removable cartridge feature contains a self-contained and self-sealing air circulation system - no preventive maintenance is required. SYSTEM CONFIGURATION I.D.: Configuration of the MDC-200 Tags, Descriptions, etc. is accomplished via Operator Keyboard or via ASCII Keyboard CRT entry. System Configuration is by the User. CONFIGURATION I.D. NUMBER: SC-UC NOTE: Prices are subject to escalation due to circumstances beyond our control.	8,089.00	8,089.00

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY: B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:

Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 10 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks FOB Calgary TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
9	1		MICON COMMUNICATION UNIT Model No.: C-200 A3 B1 C1 D0 E0 F0 G1 Multi-processor Central Communication Unit with integral line power supply. The unit can link up to 32 MICON Controllers, 1 Data Acquisition Unit, multiple color CRT's and Keyboards, multiple PC's. The Communication Unit can also control Recorders, Printers, and can interface with a Host Computer. The basic Communication Unit includes the following components: - One Master Communication Board (contains CPU, PROM & RAM). The Master connects to a maximum of seven Subcommunicators (slaves) and scans up to four Keyboards/CRT's. The master can also communicate with a Host Computer over 1-4 serial data links. The RS-232-C, 9600 BAUD interface channel is limited to 50 feet. (This limits the Keyboards/CRTs on one system to three.) - One Analog Output Control Module which provides eight Recorder output signals and two Alarm Horn contacts. Variables are selected via CRT Group Display. - One MICON Communication Termination Panel for connection of MDC-200 system components. FIRMWARE VERSION: "E" Series (Includes advanced graphic capability.) INTERFACE CABLES: 15 foot long Cable MICON SUBCOMMUNICATOR BOARD: One MICON Subcommunicator slave maintains communication with eight MICON controllers. POWER SUPPLY: 120V, 60 HZ NOTE: Prices are subject to escalation due to circumstances beyond our control.	15,550.00	15,550.00

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE:
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 11 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks F.O.B. Calgary TERMS: 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			CUSTOM CONTROL CABINET		
10	1		The Custom Cabinet is an enclosure which houses the equipment required by the user. In this case the cabinet will be a free standing 24(W) x 30(D) x 72(H) enclosure with all equipment mounted and wired. A rear door will provide access to all field device terminations. Paint Color - Standard dull gloss beige inside and out. Front Panel Cutouts - 2 P-200, 1 CRT, 1 Keyboard (on slides). Power Distribution - combination 110VAC/28VDC equipment and process power. Ventilation - integral blower.	7,110.00	7,110.00
			TOTAL PRICE		$94,160.00
			NOTE: Prices are subject to escalation due to circumstances beyond our control.		

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY:
B. R. Kukulski

CANTECH

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
SPECIALISTS IN MEASUREMENT AND CONTROL

HEAD OFFICE
CANTECH CORPORATION
1916 - 27th AVENUE N.E.
CALGARY, ALBERTA, CANADA
T2E 7A5
TELEPHONE 403-230-1581
TELEX 038-21588

SALES OFFICES
CALGARY
EDMONTON
VANCOUVER
TORONTO
SARNIA
HALIFAX
MONTREAL
WINNIPEG
SASKATOON

QUOTATION

TO:
Cambrian Engineering Group
4815 - 78 Ave. S.W.
Calgary, Alberta
T3C 2Y9

Attention: Mr. Al Hoar

No. 24-188 Page 12 of 12
Date: December 7, 1984
Office Quoting: 1916 - 27th Ave. N.E.
Calgary, Alberta T2E 7A5
Reference: Project B3333

We are pleased to submit the following quotation, subject to the terms and conditions contained on the reverse side of this page.

DELIVERY 8 - 10 weeks
F.O.B. Calgary
TERMS 30 DAYS NET **

ITEM	QUANTITY	CANTECH CODE	DESCRIPTION	UNIT PRICE *	TOTAL PRICE
			NOTES		
			1. Federal and Provincial Sales Taxes are not included.		
			2. F.O.B. Calgary, Alberta.		
			3. Duty is not included under Tariff Item 41417-2. If applicable for Items 1, 2, 3, & 4, duty would be extra at 6.3%.		
			4. Prices are in Canadian funds based on U.S. dollar equals 1.32 Canadian dollar. If the exchange rate varied more than 2% from 1.32 on date of shipment from the factory, prices will be adjusted to the rate (Bank of Canada Noon Rate) prevailing on that date.		
			NOTE: Prices are subject to escalation due to circumstances beyond our control.		

*Prices are firm for a period of 30 days from date of quotation, except when affected by our supplier's escalation policy, changes in duty, taxation, currency exchange rate, or other reasons stated under No. 1 of Terms and Conditions of Sales. Federal Sales Tax and Provincial Taxes not included unless indicated otherwise.

**Subject to Head Office Credit approval.

CANTECH CONTROLS DIVISION
CANTECH CORPORATION

BY: Brad Kukulski
B. R. Kukulski

APPENDIX 7

Business Cards

Bailey
CANADA

JOHN H. CRAIG, P. ENG.
Western Regional Manager

Bailey Controls
#14, 6120-11 Street S.E.
Calgary, Alberta
Canada T2H 2L7
Tel.: (403) 253-0271
Telefax: 03-825711

Alternate Distributed
Control System

MOORE
Process Control Systems

A. Warren Willet
Branch Manager

Moore Instruments Ltd.
11-5918 Fifth Street S.E.
Calgary, Alberta T2H 1L4
(403) 259-3919

Alternate Distributed
Control System

Dale Symington
Western Regional Manager

INTERTECHNOLOGY
INC

SUITE 317, 259 MIDPARK WAY S.E.
CALGARY, ALBERTA, T2X 1M2
TEL. (403) 256-3088
TELEX 03-827 985

SAFE 8000
Programmable I/O System

SAFE 8000

**CONTROL
MICROSYSTEMS INC.**

JAMES HOLTOM
PRESIDENT

6390 NOTRE DAME ST. W.
MONTREAL, QUEBEC, CANADA H4C 1V4
514-933-1136

Alternate Distributed
Control System

JAMES S. DRENNAN
SALES REPRESENTATIVE

225 200 RIVERCREST DR. S.E.
CALGARY, ALBERTA T2C 2X5 (403) 236 7660
FISCHER & PORTER
FISCHER & PORTER (CANADA) LIMITED

Magnetic Flow Meters

kenonic controls ltd.

Ken Netzel
President

3667 - 60th Ave. S.E.
Calgary, Alberta T2C 2E5
Telephone (403) 279-2730
Telex 03-821220

Industrial Controls and Automation
Consulting Engineering • Contracting • Maintenance

CONSULTANT - Instruments
Data Sheets by Roy Preston

CANTECH

BRIAN KUKULSKI

ENGINEER - SYSTEMS

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
250-9666

1916 - 27TH AVE. N.E.
CALGARY, ALBERTA T2E 7A8
OFFICE [redacted]

MICON Distributed Control
System

CANTECH

KEN JOHNSON
SALES REPRESENTATIVE

CANTECH CONTROLS DIVISION
CANTECH CORPORATION
250-9666

1916 - 27TH AVE. N.E.
CALGARY, ALBERTA T2E 7A8
OFFICE [redacted]

MICON Distributed Control
System

ROSEMOUNT
INSTRUMENTS
LTD

R.C. (RICK) GORDON
Sales Representative

#210, 8025 - 12 Street S.E.
Calgary, Alberta
T2H 2K1

TEL (403) 259-5647
TOLL FREE 1-800-661-1035
TELEX: 03-826520

Rosemount

Alternate Distributed
Control System
Instruments

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Dr. A.I.A. Salama

Research Scientist
Coal Beneficiation
Research Unit
Coal Research
Laboratory

Chercheur scientifique
Unité de recherches sur
l'enrichissement du charbon
Laboratoire de recherches
sur le charbon

Canada

SCIENTIFIC AUTHORITY
for this project

**the cambrian
engineering group
limited**

R. Alan Hoar, P. Eng.
Mechanical Supervisor

4815-78th Avenue S.E., Calgary, Alberta T2C 2Y9
Phone (403) 236-3553, Telex 038-25872

PROJECT ENGINEER and
PRIMARY CONSULTANT

AMCL **Associated
Mining Consultants Ltd.**
Suite 1400, 840 - 7 Avenue S.W.

ALAN L. CRAVEN, P.Eng.
Manager

P.O. Box 6500, Station D, Calgary, Alberta, T2P 2V8
Tel: (403) 264-9496 Telex: 038 27537

CONSULTANT - Process
and Ash Analyzer

geer energy ltd.

#7, 6120 - 11TH STREET S.E., CALGARY, ALBERTA T2H 2L7

Ty Patrick
APPLICATIONS & MARKETING

TELEPHONE (403) 255-0107
TELEX 038-27522

RES (403) 246-0910
TOLL FREE 1-800-342-2322

Variable Frequency
Speed Controllers

ZAZULA PROCESS EQUIPMENT LIMITED
1526 - 10th AVENUE S.W.
CALGARY, ALBERTA T3C 0J5

CHARLES E. HILTON, B.Sc.
Chemical Engineer

Bus. (403) 244-0751
Res. (403) 284-1576

Reagents Pump and Tanks

Guy A. Fiset

SPARTAN CONTROLS LTD.

2810 - 12 St. N.E., Calgary, Alberta T2E 7P7
Bus.: ~~280-4581~~ Res.: 285-4477
250-7600

Fisher Valves and
Instruments

Rick Broenink

HAL DAWSON
SALES REPRESENTATIVE
ELECTRONIC INSTRUMENTS
Hewlett-Packard (Canada) Ltd.

HEWLETT
PACKARD

3030 - 3rd Avenue N.E., Calgary, Alberta T2A 6T7
Telephone (403) 235-3100

Instrumentation Specialists

FRANK PINTYE
TECHNICAL SERVICE REPRESENTATIVE

GALVANIC INSTRUMENT SERVICES
Div of G.A.S. Ltd
9202 HORTON ROAD S.W.
CALGARY, ALBERTA
T2V 2X4

BUS (403) 253-4144
TELEX 03-822667

Inside.Sales - Jim Algeo

Davis Controls

JOHN WIGGINS
Technical Representative

100 - 9805 Horton Rd. S.W.
Calgary, Alberta, Canada
T2V 2X5

Telephone: (403) 252-5855
Telex: 03-821113 Telsec CGY
Order Entry and Expediting
Telephone: 1-800-232-1959

APPENDIX 8

The Ash Analyzer

DEVELOPMENT OF A FROTH FLOTATION CONTROL SYSTEM

DSS FILE NO. 03SQ.23440-3-9048

→ National Coal Board

NCB/AERE ASH MONITOR - NOTES

→ Atomic Energy Research Establishment

1. A visit was made on November 15, 1984 to MRDE, Bretby, to discuss the supply of ash monitors for the EMR Pilot Plant, Devon, and to obtain relevant data.

2. Attached are:

   - 'A Technique for Measuring the Ash Content of Coal in a Tailings Stream'
     by I.S. Boyce, AERE.
   - 'Performance Trials of an Instrument to Continuously Monitor for Ash Content of a Tailings Slurry'
     by S. Ivatt, MRDE.

   This is a draft report and must remain strictly confidential - not to be passed on to EMR.

3. Present electrics operate on 240 V. The electrical power details will have to be confirmed when an order is placed.

   Control signal outputs are 4 - 20 ma.

4. Layout for tailings ash monitor should be basically as Figure 8 of paper by S. Ivatt. The tailings would pass to monitor with minimum 15 ft. head. An overflow arrangement is required.

   Overflow from monitor passes to new sump from which it is pumped to slimes tank.

5. For feed slurry the deaerator may not be required. Can take pump feed straight up through monitor, provided velocity is high enough.

6. Preliminary calculations show that the velocity of the feed in 76 mm pipe from feed tank is too low at the minimum flowrates shown on our drawings. Material will settle out.

   Area of Pipe $= \frac{\pi}{4} \; 0.076^2 \; m^2$

   Flowrate $= 15 \; m^3/h = \frac{15}{3600} \; m^3/sec$

   Velocity $= \frac{\text{Flowrate}}{\text{Area}} = 0.918$ M/sec = 3.0 ft./sec

   The feed from the fines tank should be maintained at a minimum 25 m^3/h to give acceptable flow velocities. Alternatively the pipe diameter could be reduced with adverse effects on existing instrumentation.

   Thus the control system proposed with headbox may not be practical. Dilution water could be added to fines tank or preferably into pump suction.

7. **Budget Prices**

   Ash Monitor 44,000 Pounds Sterling (each)
   plus: Shipping and insurance at cost.

   Commissioning:

   One AERE plus one MRDE engineers required for set-up and calibration. 2 manweeks @ \$500 per day = \$5,000
   Expenses: Airfares plus subsistence at cost, estimated as \$6,000

It is recommended that MRDE engineer visit site at time of order to ensure method of application is satisfactory and to finalize details. Cost of Site Visit $2,000 fees, plus $3,000 expenses.

If two ash monitors are purchased at the same time then there could be a reduction of approximately 10% in the price of each machine and no additional commissioning or pre-delivery Site Visit costs.

Price Summary

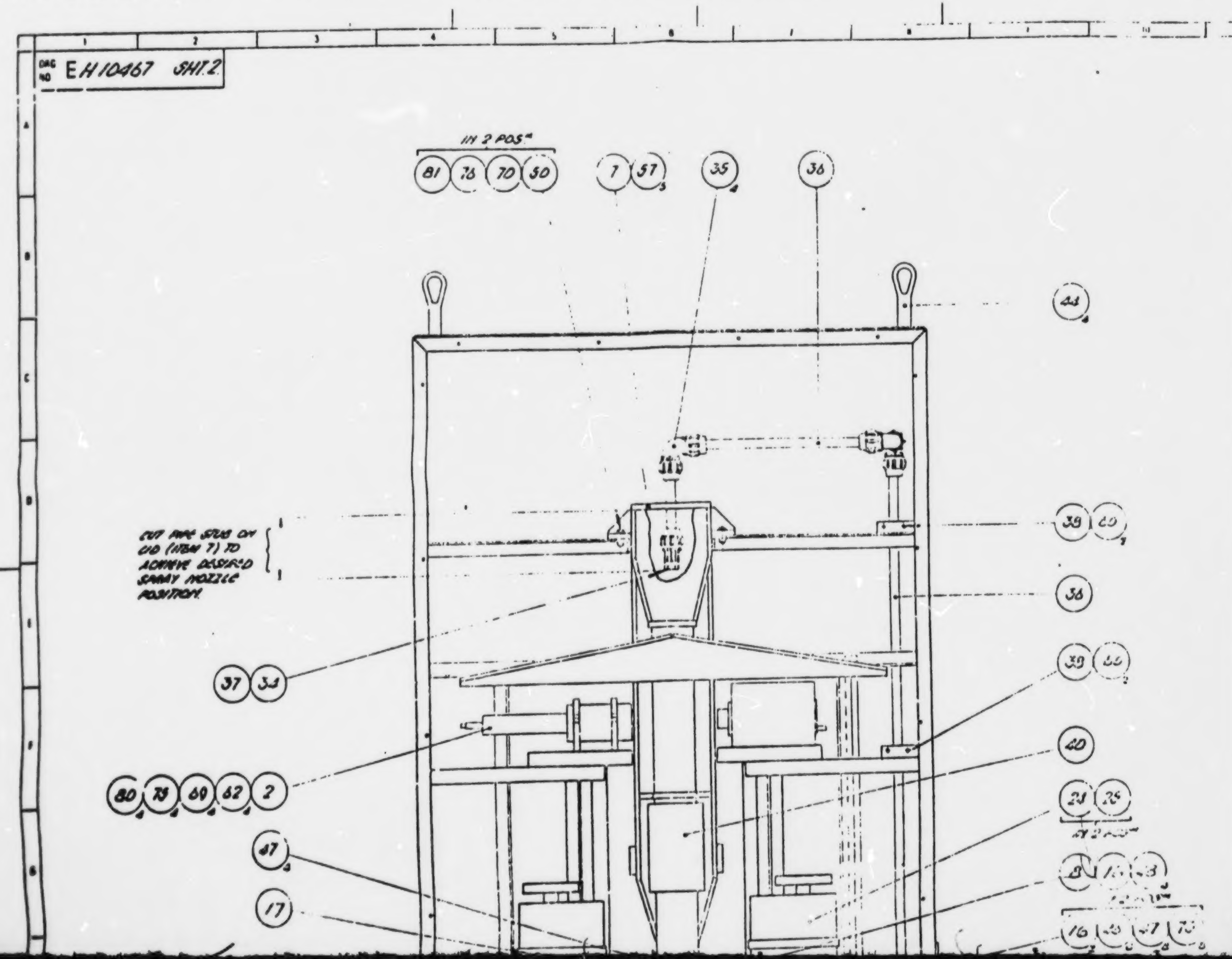
Ash Monitor 44,000 Pounds Sterling @ $1.70	$ 74,800
Shipping and insurance (estimate)	3,000
Commissioning	11,000
Pre-delivery Visit	5,500
	$ 94,300

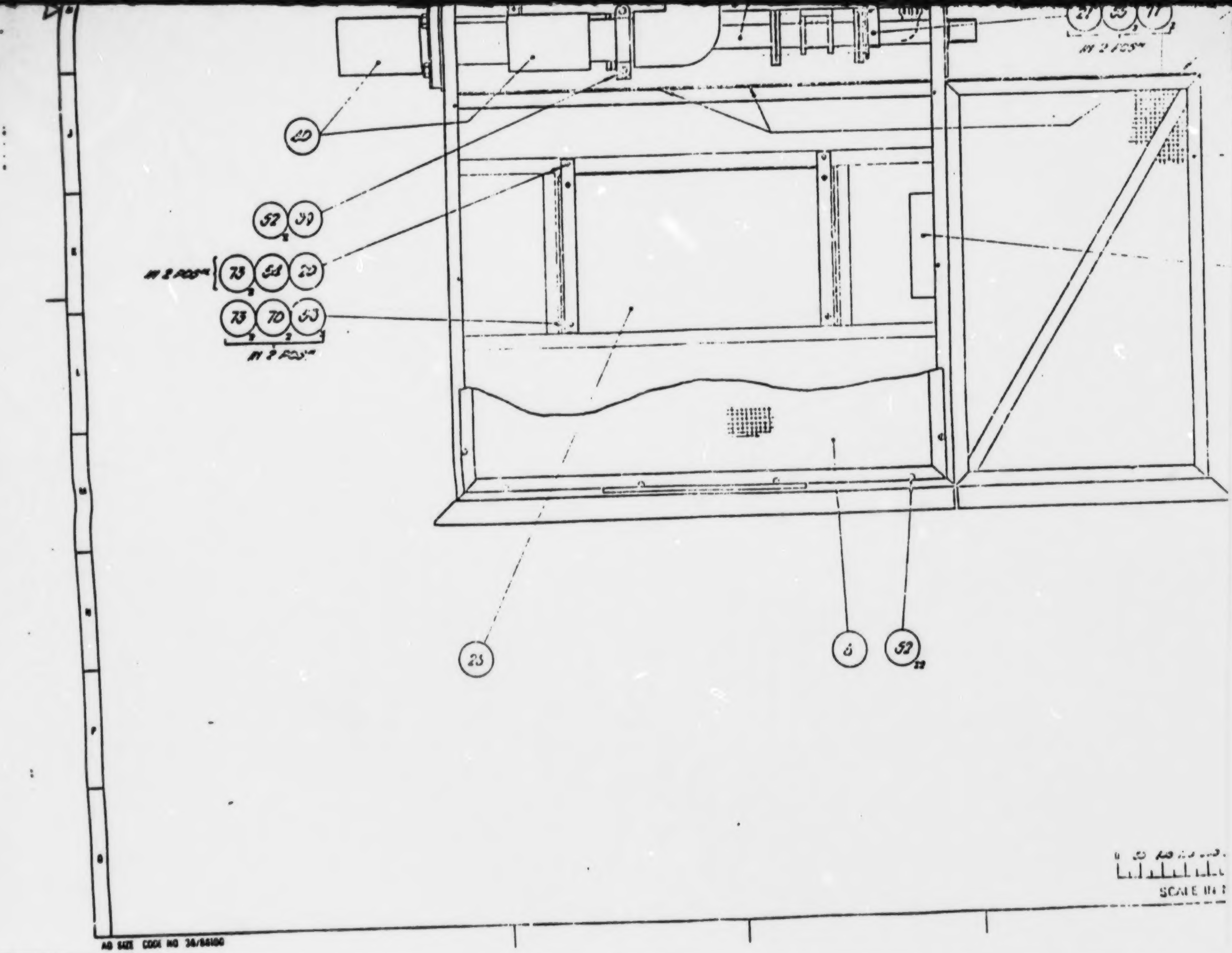
The above equipment may be obtained through AMCL for a 5% Procurement Fee.

8. As previously stated, no guarantees can be given regarding the accuracy of measurement of the ash monitor, since it is developed to the pre-production stage only.

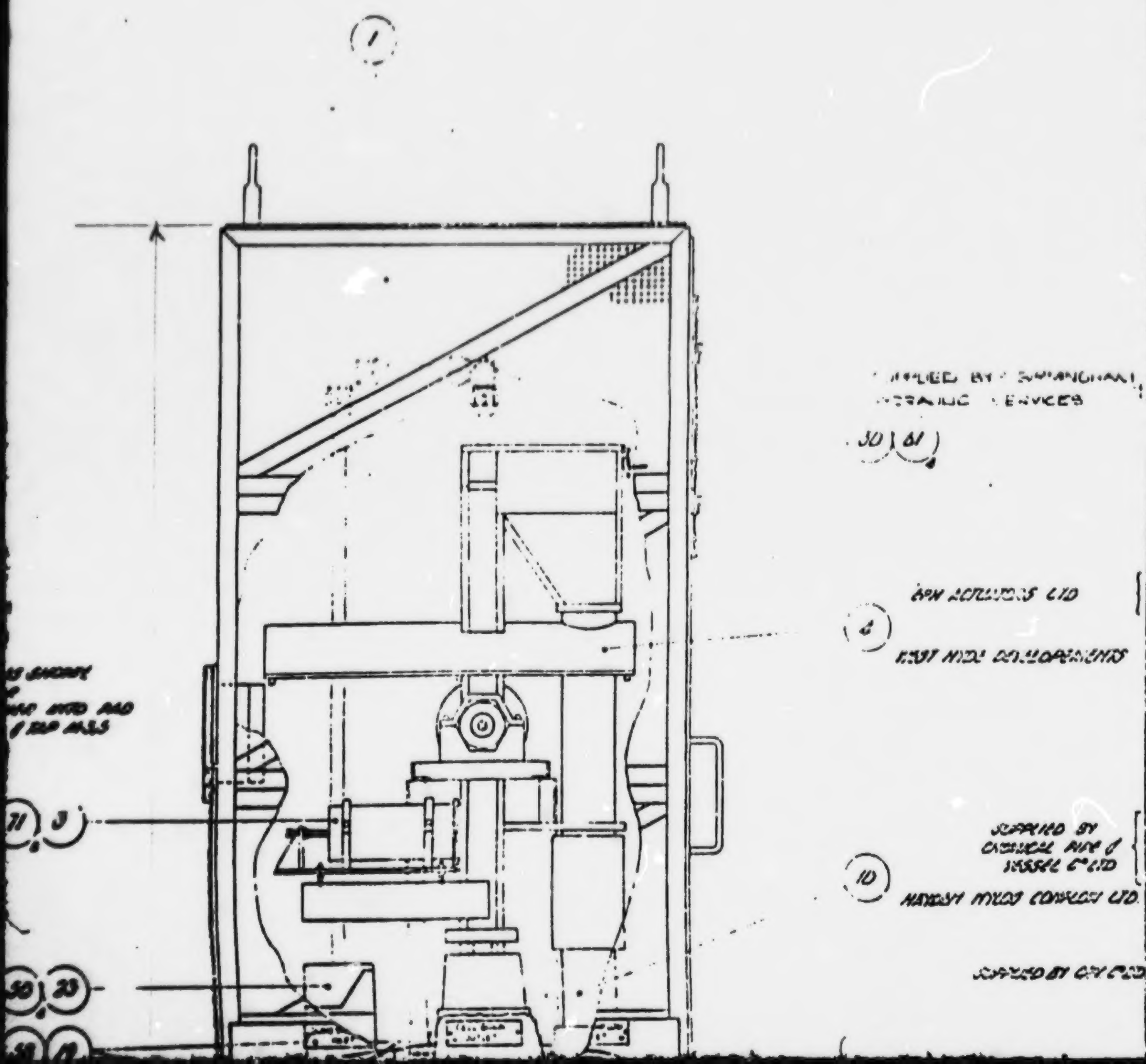
Normal 12-month warranties apply to the equipment and electronics due to faulty manufacture.

Alan L. Craven, P.Eng.


DWG NO EH10467 SHT.2
IN 2 POS'
CUT PIPE STUB ON LID (ITEM 7) TO ACHIEVE DESIRED SPRAY NOZZLE POSITION.


IN 2 POSNS
IN 2 POSNS
IN 2 POSNS
SCALE IN
A0 SIZE CODE NO 36/86100

PROJECTION



SUPPLIED BY ... HYDRAULIC SERVICES

APN ACTUATORS LTD

EAST MIDS DEVELOPMENTS

SUPPLIED BY CHEMICAL PIPE & VESSEL C° LTD

HAYDEN MIDS CONTROLS LTD.

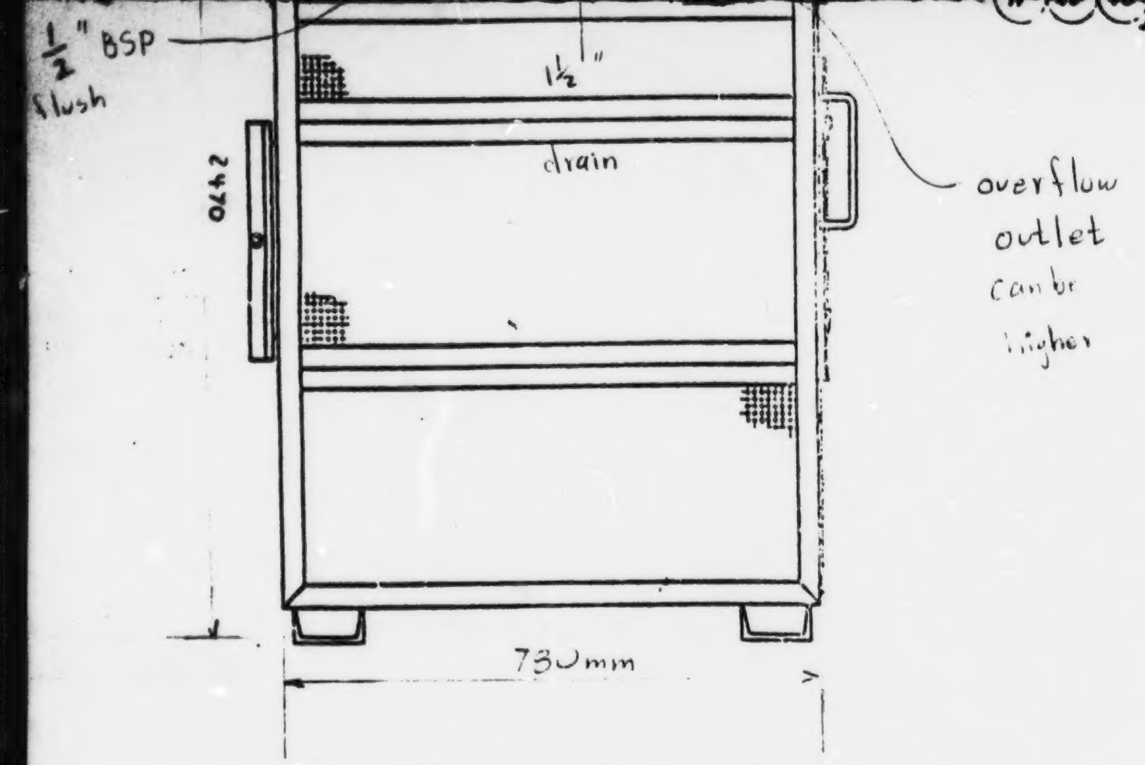
SUPPLIED BY CPV LTD

[illegible]

FLOWCELL ASSEMBLY No 1

FLOWCELL ASSEMBLY No 2 [illegible]

ITEM NO	DRG NO or CODE NO	DESCRIPTION	[illegible]	[illegible]
1	CH10357/001	FRAMEWORK ASSY	1	1
2	CH10357/002	COLLIMATOR BASE ASSY	1	1
3	CH10357/003	X RAY GAUGE + BASE ASSY	1	
4	CH10357/003	FLOWCELL ASSY	1	
5	CH10357/017	DOOR (LARGE)	1	
6	CH10357/008	BACK PANEL ASSY		
7	CH10357/021	LID ASSY	1	
8	CH10357/006	TEE PIPE ASSY	1	
9	CH10357/007	STRAIGHT PIPE ASSY	2	2
10	CH10357/010	FLOWCELL ELBOW ASSY	1	1
11	CH10357/011	FLOWCELL STRAIGHT ASSY	2	2
12	CH10357/018	FRAMEWORK ASSY (SMALL)	1	
13	CH10357/022	FLANGE PIPE ASSY	1	
14	CH10357/11	COVER	1	
15	CH10357/17	ESCUTCHEON	1	
16	-	GASKET ANSI 150	5	5
17	CH10357/6	GASKET (LARGE)		
18	CH10357/10	PLATE	3	3
19	CH10357/14	LABEL	4	4
20	CH10357/9	BOX MOUNTING STRIP	2	
21	CH10357/18	SUPPORT BRACKET	2	
22				
23		BALL VALVE C/W ACTUATOR 1½" NB TYPE 3	1	
24		BALL VALVE 1½" NB	2	2
25		ACTUATOR RCS TYPE	2	
26		BOX CL 1505 RITTAL	1	1
27		BOX EDA 135 SORAL [illegible]	1	1
28		BOX EDDYSTONE RADIO TYPE 9920P	1	
29		HINGE TYPE AS 1033/25 [illegible]	1	1
30		FASTENER TYPE 18-613 [illegible]	1	1
31		FASTENER TYPE 29-369 [illegible]	2	2
32	[illegible]	PADLOCK	2	2
33				
34		FEMALE ADAPTOR TYPE 7030 20×½	1	1
35		ELBOW 90°-TYPE 7050-20	4	4
36		PIPE TYPE NG 20 OD [illegible]	[illegible]	[illegible]
37		ECONOMY SPRAY HEAD. CODE 1756	1	1
38		PIPE CLIP ½" [illegible] 103-102	2	
39		PIPE CLIP 3" [illegible] 103-109	1	
40		PIPE COUPLING PUSH ON	3	
41				
42		BACKING RING ½" TYPE [illegible] 20		
43		BACKING RING 3" TYPE [illegible] 50	1	



49	23/41394	BOLT M12 x 40 LG HEX HD STL	4	4
50	23/41390	BOLT M8 x 30 LG. HEX HD STL	6	6
51				
52	23/47703	SCREW M3 x 25 LG. CSUNK HD STL.	2	2
53	23/48836	SCREW M3 x 20 LG. HEX. HD. STL.	4	4
54	23/50186	SCREW M5 x 15 LG. PAN HD STL.	2	2
55	23/52232	SCREW M6 x 12 LG HEX HD. STL.	33	30
56	25/50184	SCREW M6 x 12 LG. PAN HD STL.	70	[illegible]
57	23/50197	SCREW M8 x 16 LG. PAN HD. STL.	5	5
58	23/50136	SCREW M4 x 10 LG PAN HD STL.	33	33
59	23/50220	SCREW M3.5 x 10 LG PAN HD STL.	8	8
60	25/37641	SCREW M3 x 10 LG. CSNK HD. STL.	4	4
61	23/37639	SCREW M3 x 6 LG PAN HD STL.	4	4
62	23/39747	CAPHEAD M10 x 30 LG. STL	4	4
63	23/39708	CAPHEAD M16 x 28 LG. STL.	4	4
64	23/39688	CAPHEAD M5 x 25 LG STL.	4	4
65				
66				
67		NUT, M16 HEX STL GRADE 8	23	23
68	23/57811	NUT, M12 HEX STL GRADE 8	4	4
69	23/57810	NUT, M10 HEX STL GRADE 8.	4	4
70	23/57849	NUT, M8 HEX. STL ZINC PLT	6	6
71	23/57843	NUT, M6 HEX STL ZINC PLT	6	3
72				
73		WASHER, PLAIN M16 STL (MAT)	23	23
74	23/77868	WASHER, PLAIN M12 STL (MAT)	4	4
75	23/77851	WASHER, PLAIN M10 STL (MAT)	4	4
76	23/78180	WASHER, PLAIN M8 STL ZINC PLT	6	6
77	23/78179	WASHER, PLAIN M6 STL. ZINC PLT	12	12
78	23/78177	WASHER, PLAIN M4 STL ZINC PLT	6	8
79				
80	23/78351	SINGLE COIL WASHER M10 STL.	4	4
81	23/78360	SINGLE COIL WASHER M8 STL.	[illegible]	2
82				
83	23/59408	STUDDING M8 x 40 LG STL.	4	4
84				
85				

DRAWING TO BS 308	USED ON	MATL & SPEC SEE ITEM LIST.	FINISH	NOT FOR PUBLICATION THE INFORMATION ON THIS DRAWING IS NOT TO BE COMMUNICATED EITHER DIRECTLY OR INDIRECTLY TO THE PRESS OR TO ANY PERSON NOT AUTHORISED TO RECEIVE IT
STUDY NO.		TOLERANCES UNLESS STATED	SURFACE TEXTURE UNLESS STATED	REMOVE BURRS & SHARP EDGES
ADAPTED S DRG				DIMENSIONS IN mm

JOB NO	DRN AIN FIRCO		
PROJ NO	CHKD		
	APPD	ISSUE	DATE

UKAEA LABORATORY--

ORIGINAL SCALE: 1:5

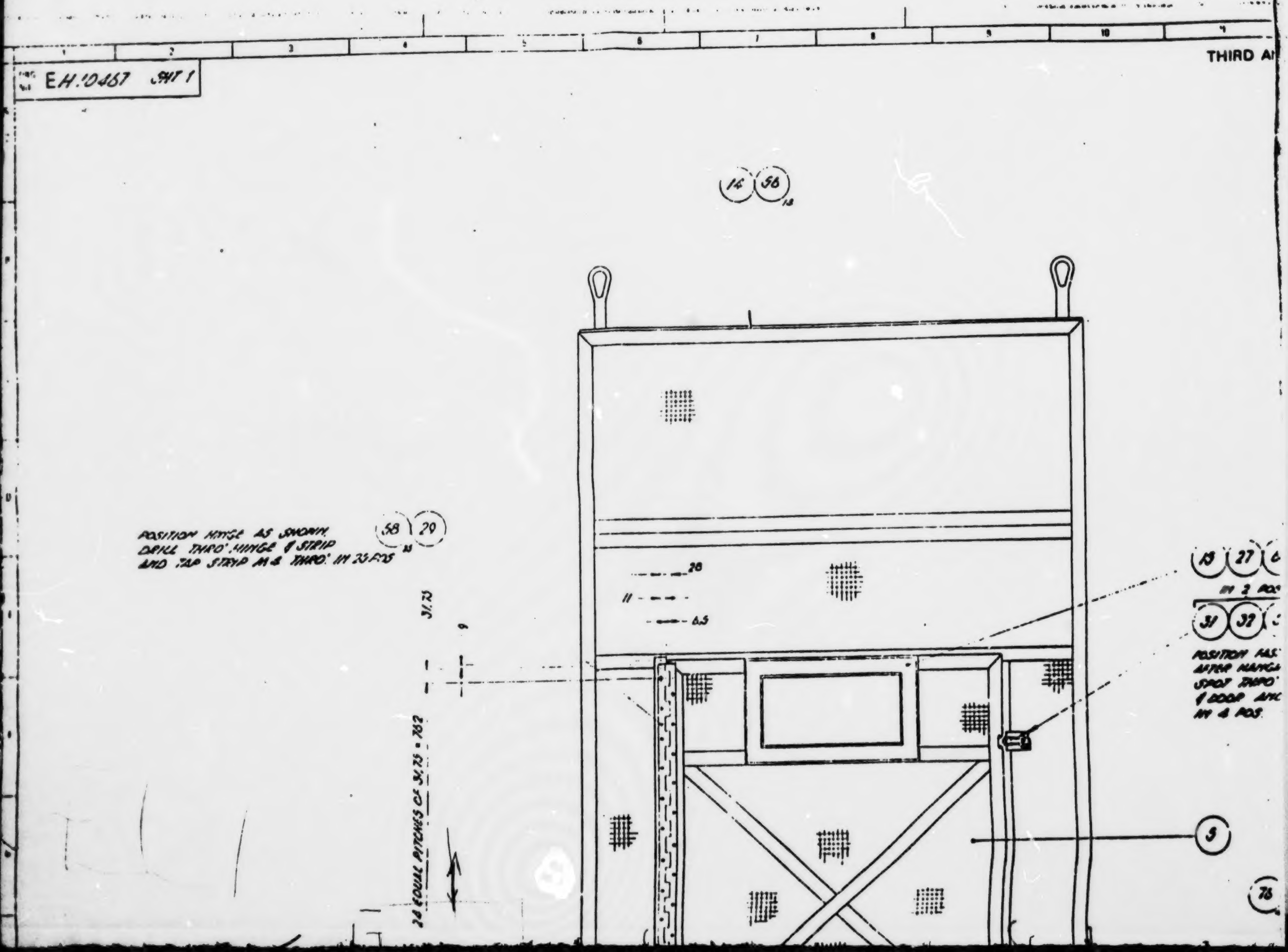
TITLE: FLOWCELL ASSEMBLY MK II.

QUALITY ASSURANCE APPLIES

QA SCHEDULE

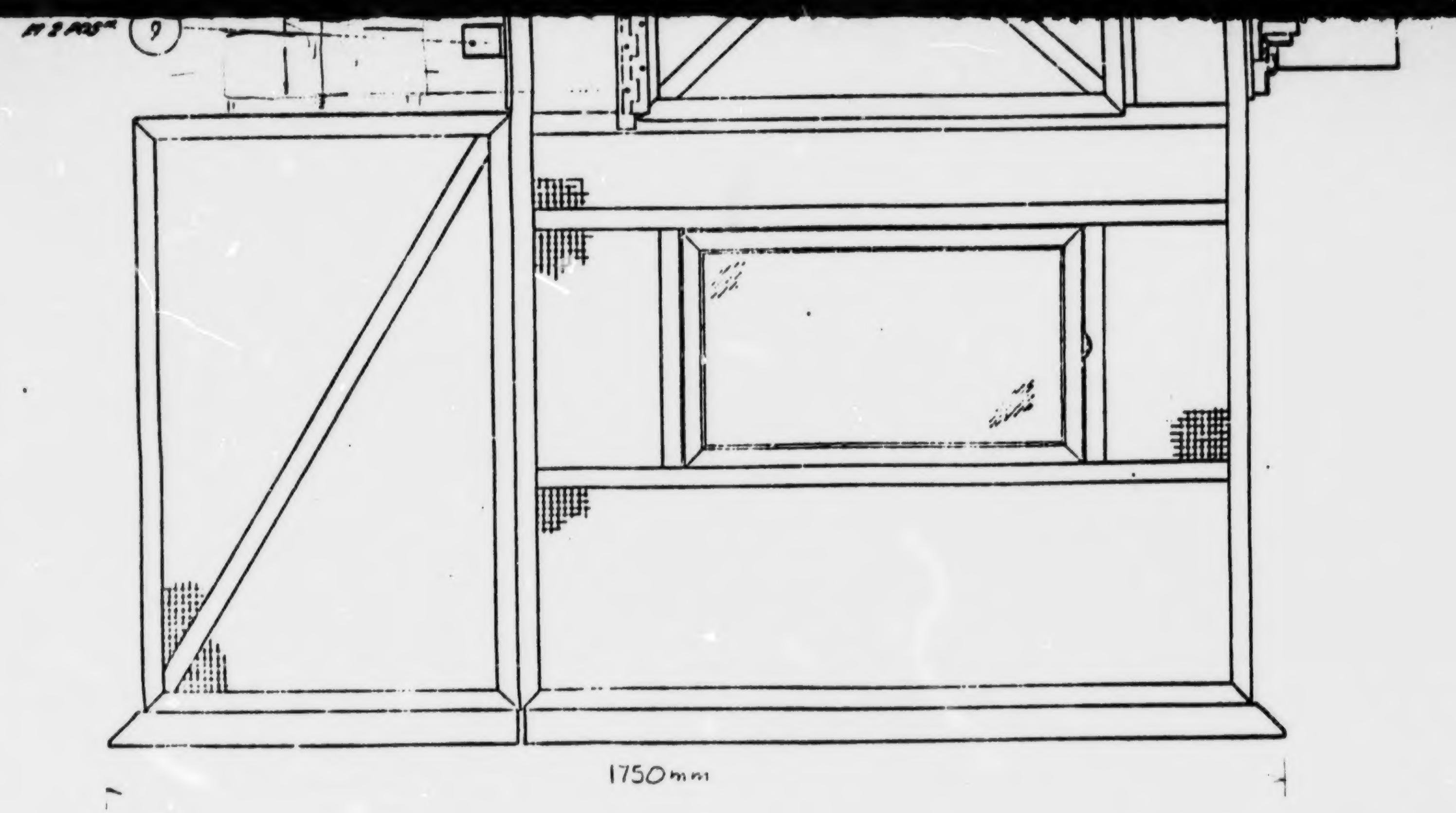
DRG NO EH 10467

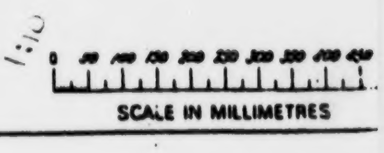
EH.10467 SHT 1


1
2
3
4
5
6
7
8
9
10
11
THIRD A
14
56
13
58
29
33
28
11
6.5
31.75
6
28 EQUAL PITCHES OF 31.75 = 762
13
27
IN 2 POS
31
32
5
78

POSITION HINGE AS SHOWN.
DRILL THRO'. HINGE & STRIP
AND TAP STRIP M 5 THRO'. IN 33 POS

POSITION FAS
AFTER HANGI
SPOT THRO'
& DOOR ANC
IN 4 POS.


Nº 2 POSⁿ
9
1750mm

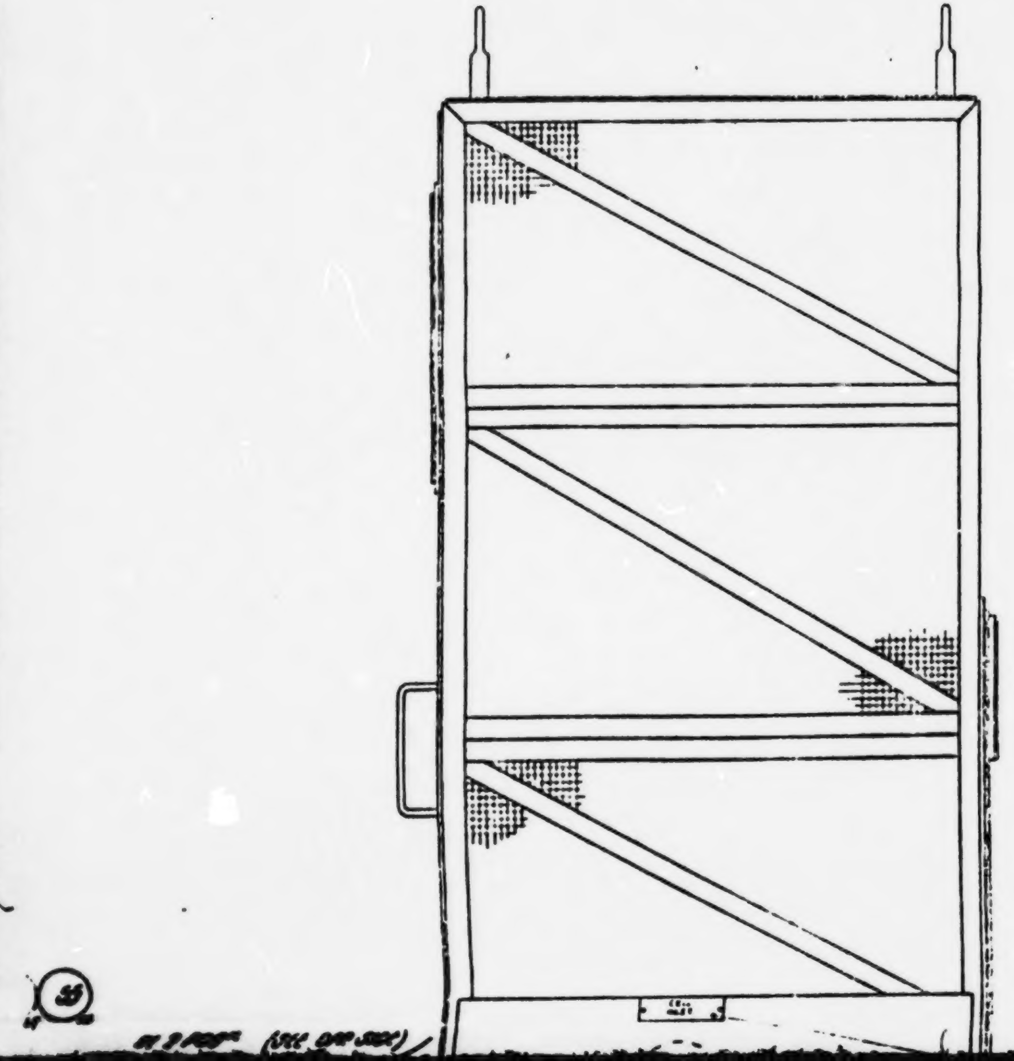

1:10
0 50 100 150 200 250 300 350 400 450
SCALE IN MILLIMETRES

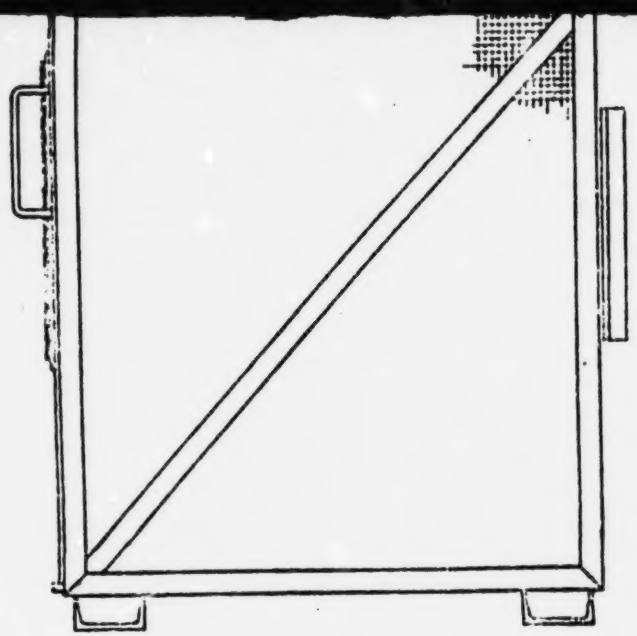
A0 SIZE COUN NO 38/86108

12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21

PROJECTION

EQUIPMENT		
ITEM NO	DRG NO OR CODE NO	DESCRIPTION


35
(SEE DRG SIDE)



MARKING [illegible] TO [illegible] 306	USED ON	MATL & SPEC [illegible]	FINISH	NOT FOR PUBLICATION THE INFORMATION ON THIS DRAWING IS NOT TO BE COMMUNICATED EITHER DIRECTLY OR INDIRECTLY TO THE PRESS OR TO ANY PERSON NOT AUTHORISED TO RECEIVE IT	[illegible]	DRN [illegible] (PHILCO)	[illegible]
		TOLERANCES	SURFACE FINISH		[illegible]	CHKD	[illegible] DATE [illegible]
[illegible]						APPD	
.100 .005		[illegible] STATED	∇ UNLESS STATED	REMOVE BURRS & SHARP EDGES	UKAEA LABORATORY–		[illegible]
				[illegible] 2:1	ORIGINAL SCALE 1:5	TITLE FLOWCELL ASSEMBLY MK II	EH 10

APPENDIX 9

Basis for Phase III Design

- October 19, 1984 letter
- October 28, 1984 meeting

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Research and Technology
Recherche et Technologie

Canada Centre for Mineral and Energy Technology.
Centre canadien de la technologie des minéraux et de l'énergie.

Coal Research Laboratories
Laboratoires de Recherches sur le Charbon

P.O. Bag 1280
Devon, Alberta
T0C 1E0

Your file Votre référence

Our file Notre référence

October 19, 1984

Mr. R. Alan Hoar,
Project Engineer
The Cambrian Engineering Group Ltd.
4815-78th Avenue S.E.,
Calgary, Alberta
T2C 2Y9

Dear Sirs:

RE" "Phase II-Preparation of Alternatives" Report, "Development of a Coal Froth Flotation Control System" Contract

Please find enclosed a copy of the CRLE evaluation of "Phase II-Preparation of Alternatives" report submitted by the CEGL as a fulfillment of phase II of the above named contract. Based on the evaluation the report is acceptable.

We appreciate the effort invested by the CEGL on this project, and we look forward to the successful completion of a novel process control system for coal flotation.

Yours truly,

Dr. A.I.A. Salama
Research Scientist
CRL/Edmonton

AIS/vlm
Enclosure

c.c. P.J. Monnelly, DSS

Canada

"Phase II - Preparation of Alternatives" Report Evaluation

After careful and thorough examination of the report and mutual discussions between the S.A. and specialized CRLE members in the areas of: Flotation, Coal Preparation and Process Control, the CRLE evaluation can be presented in two parts. Part #1 is the detailed comments on the report and Part #2 is our overall recommendations on the report.

PART #1 - DETAILED COMMENTS

1 - Water Composition - pH meter can be included, page 4,: should be included

2 - FC10 receives a set point (manually) and compares......, page 6. Another alternative is to use AC speed controller to vary the discharge pump r.p.m. to avoid size segregation.

3 - 2.2.3 Option IB, page 6. LT10 is not shown in drawing number IB as discussed in the text.

4 - Option IE, page 8. Not a priority at this stage.

5 - Option IF, page 9. Too complicated at early stage of testing and development.

6 - Option IG, page 10. Not feasible at this stage due to space limitation.

7 - pH Control - Drawing IH, page 10. See comment #1.

8 - Specific Power Input Control - Drawing IH, page 11. It is advisable to allow for the inclusion of such system for research needs. This system need not to be controlled on a continuous basis.

9 - Figure 3.1, page 15. The figure is confusing, may be due to error in the arrows as shown.

10 - Operator Search Controller, page 20. Due to the time delay involved, it is impractical control system.

11 - b) Model-Based Controller, page 23. Some confusion exits between availability of state variables and noisy measurements of the states. Unavailability of state variables can be overcome by the design of a "Luenberger Observer", however noisy state measurements can be overcome by the design of a "Kalman Filter".

12 - b) Model-Based Controller, page 24. This area needs some investigation; the possible inclusion of an adaptive scheme should be considered.

13 - Figures 3.2 and 3.3, see comment #9.

14 - Section 4.2 Basis of Selection, page 25. CRLE is using the pilot plant for:

i) Fundamental and applied R & D for coal flotation

ii) Demonstration of control strategies and process control schemes that benefit the Canadian Coal Industry,

with emphasis on objective #ii.

- Section 4.3 Independent Operation, page 26. It can be run without WOC circuit, however one needs desliming coarse cleaning and water recovery.
- Section 4.3 Independent Operation, page 27. The installation of additonal storage is not feasible at this stage, however CRLE may consider it in the future.
- Section 4.4 Feed Control, page 28. Eventually we are going to need one. The pH monitor and control, see comment #1.
- Section 4.5 Modifications to cell, page 28. Air flowrate to be measured and automatically controlled, air pressure to be measured. Automatic Control of impeller speed is required.
- Power Input, page 29. It is desireable to have this feature for research needs. Air flow, impeller speed and power input group should be discussed to determine the merits of automatic control of this group.
- Product Measurements, page 29. On tailings stream, we require these instruments: Density/Solids concentration, flowmeter, ash monitors.

RT #2 - OVERALL RECOMMENDATIONS

- The detailed development of Ash measurement on concentrates ~~directly~~ or indirectly is needed.
- Due to space limitations options IE and IF are eliminated at this stage, however detailed design information related to these two options is needed for future consideration.
- CRLE requires to start with workable base (for example Options ID) with a flexibility that we can utilize to build on to develop more sophisticated control schemes (such as Options IH and 3.9), CRLE expects in the next stage:

i - A detailed multilevel design approach, where a higher level control scheme that includes all the lower level schemes be developed.

ii - Detailed mechanical and electrical design, instrumentation specifications, microprocessor or computer specifications and software for the detailed multilevel design approach.

4 - Available software on Kalman algorithm and flotation process model are required.

5 - "Phase II - Preparation of Alternative" report is generally acceptable.

S.A. ______________

Date: October 19, 1984

CRL, Edmonton

Froth Flotation Control System the cambrian engineering group limited **B3333**

Meeting Notes **Issued: 84 11 01**

Date: October 28, 1984

Attendance:		
	Magdy Mikhail	Coal Research Lab
	Ahmed Salama	Coal Research Lab
	Al Hoar	Cambrian
	Alan Craven	AMCL

1. General

The meeting subject was review of our Phase II Report and the objective was to establish which alternate system would be chosen for detailed design.

This objective was met; a system was chosen for detailed design.

2. Review of the "Overall Recommendations" contained in October 19 letter from Dr. Salama.

2.1 Detailed development of ash measurement of concentrates directly or indirectly was discussed.

- We are not expected to attempt to measure ash on the froth product.
- Directly in this sentence means using ash monitors and two would be required - one on feed and one on tailings, because the froth cannot be measured.
- Indirectly in this sentence means using the density of the solids to determine ash by an ash density relationship which is a characteristic of each kind of coal.

There was much discussion about this point. Ahmed Salama and Magdy Mikhail explained a mathematical way of determining density of the solids by using percent solids in the slurry, and density of the slurry; both measurements taken from the K Ray nuclear gauge on the feed stream.

Alan Hoar and Alan Craven expressed their belief that the measurements of percent solids in and density of the slurry are not two measurements but rather one measurement with two interpretations based on two calibrations of the K Ray. We believe that the percent solids as produced from the K Ray nuclear gauge is an interpretation of the density of the slurry using density of the solid and density of the liquid to make this interpretation.

This question will receive further thought from both parties.

2.2 Options IE and IF eliminated. It was agreed that this means do not detail design the options with a new flotation feed tank.

2.3 The base for detailed design of piping and instrumention is to be:

A combination consisting of

.1 Option IF but without the new flotation feed tank. This can also be stated as Option ID but with feed forward control of clarified water added to a feed box just before the flotation cells.

.2 An ash analyzer for feed and for tailings.

.3 Instruments to measure flow and density (or solids %) of tailings.

.4 Instruments to measure variables for Specific Power Input calculation. These are 6 measurements of torque, 6 measurements of air, 3 controllers for speed.

.5 A controller for feed regulation and control of reagents. It was discussed and generally agreed that these control loops would be implemented with a multi loop digital process controller such as MICON.

.6 A controller for specific power input. This would perhaps be a desk top micro computer.

.7 The device of Point 6 would be capable of using information from all sources to implement complex model based control strategies.

2.4 Specific points to be included in detailed design:

.1 Indicators required

	Local (at the instrument)	Remote (in control room)	Screen (CRT)
K Ray Density	No	Yes (existing)	Yes
Feed Flow Meter	Yes	No	Yes
pH	No	No	Yes
Frother Flow	No	No	Yes
Collector Flow	No	No	Yes
Mass Flow Rate			Yes
Impeller Speeds			Yes
Torque			Yes
Air Flow	Yes	No	Yes
Specific Power			Yes
Tailings Flow			Yes
Tailings Density	No	Yes	Yes

.2 **Frother/Collector**

Design tanks for frother and collector, each about 30 liters size.

Use tubing pumps for variable flow from these tanks.

.3 Control devices must be able to send their data and receive data (setpoints) from the HP1000.

Communications via RS232 preferably at 9600 baud, or via HP-IL or via Allen Bradley Data Highway configuration.

.4 Control of Motors

There are 6 motors associated with the froth flotation process

1 - Feed Pump
3 - Impeller Motors
2 - Froth Paddle Motors.

The starting and stopping of all these motors is done by the Allen Bradley PCL 2/30. Flotation Control system does not have to communicate with the PLC. This means that froth system does not know the status of these motors unless told by an operator. Froth system controls the speed of three impeller motors and one pump motor but these motors are started or stopped by PLC.

3. Review of the "Detailed Comments" Portion of October 19th Letter from Dr. Salama.

3.1 Include pH Monitoring

3.2 Existing pump is variable frequency AC drive. Can accept a current loop signal to vary the pump speed. Use this method instead of the bypass FCV 10.

3.3 True LT 10 should be on IB drawing.

3.4 No design for new tank.

3.5 No design for new tank.

3.6 Do not design outdoor tank.

3.7 pH monitoring only is required.

3.8 Include instruments and calculations for specific power input.

3.9 Not important.

3.10 Operator search controller is ruled out.

3.11 No comment.

3.12 Model Based Controller. Available software is desired. Computer to be capable of handling. The main point of this comment was to differentiate between an optimizing scheme and an adaptive scheme.

3.13 Not important.

3.14 Because of item ii), "CRLE is using the pilot plant for demonstration of control strategies and process control schemes"; the idea of using a multi loop digital process controller to implement the normal PID loops is acceptable to CRLE. In fact a preference was indicated for using this method.

3.15 No detailed design will be directed toward allowing control while the cyclones are operating. In other words feed will bypass this section while froth flotation control system is being used.

3.16 No storage of feed.

3.17 pH monitor only, not pH control.

3.18 Measure and control air flow to each cell. Control impeller speeds (3 motors). Measure torque - 6 places.

3.19 Include Specific Power Input Calculation.

3.20 Measure density, flow, ash monitor on tailings stream.

4. Tour of the Pilot Plant

These items were noted:

4.1 We were shown a manual for the K Ray gauge and promised a copy.

4.2 I/O for Froth Flotation Control System is not to go through PLC 2/30.

4.3 Heavy Media System Hardware is:

Screen	Execl 24	Monochrome Green
Keyboard	Execl 24	
Printer	Decwriter III	also has keyboard
Processor	Micromaster CPU, Memory, Clock, Logic, Parallel I/O.	

The system was designed by DATAP Systems. It is a one time design.

4.4 Heavy Media System Software

Screen shows a Main Menu

Selections are made by entering 2 numbers on keyboard. Control actions can be taken when on certain pages.

Other pages are a system graphic, system history, status, and others.

4.5 K Ray

The indicator and electronics are quite large. Two units are in one cabinet.

4.6 The flow meter has these names on it - Polysonics and Rosemount. Vendor was Davis Controls in Edmonton. Rosemount is the transmitter.

4.7 For measurement of the tailings stream there is only four feet of vertical height available. This may not be enough for ash monitor. Also the existing arrangement does not provide a full pipe.

4.8 Tank Level Control

Presently installed is a diaphragm operated valve. A Fisher I to P transducer provides the varying air pressure signa. Where does the current signal come from? 4-20 ma signal in / 3-15 psi signal out.

Electrical connections and instrument air was not installed.

We did not see where there would be a 4-20 ma signal representing the level of the cells. The signal to the I/D transducer only represents the valve position.

4.9 Variable Speed Drive - Feed Pump

AC Speed Control Cabinet has this label:

A.C.S. Canadrive, One Automatic Road, Brampton, Ontario (416)791-1020
Serial No. 81D6252
4632-2.

4.10 Allen Bradley PLC 2/30

This PLC has 2 racks of remote I/O in the motor control center. It also has 2 racks of I/O locally. Many spaces exist now but will be used. There is some Analog input and output.

Its purpose is sequential starting of any chosen pilot plant flow option. Programming not done yet.

It is not necessary for froth flotation control system to communicate with the PLC.

5. Tour to Computer Room

At the terminal (screen and keyboard) for the HP 1000 we met Ian Parsons.

He explained verbally what the HP 1000 was to do regarding the froth flotation plant.

This computer is intended to be able to communicate with

- the Allen Bradley PLC 12/30 via Allen Bradley data highway,
- the Heavy Media Processor,
- the Froth Flotation System,
- others as they are introduced.

Use Allen Bradley Data Highway or HP-IL or RS232 preferably at 9600 baud.

The HP should be able to receive all data from the froth flotation control system and also to control all outputs or all setpoints of the froth flotation system.

RA Hoar

R. A. Hoar

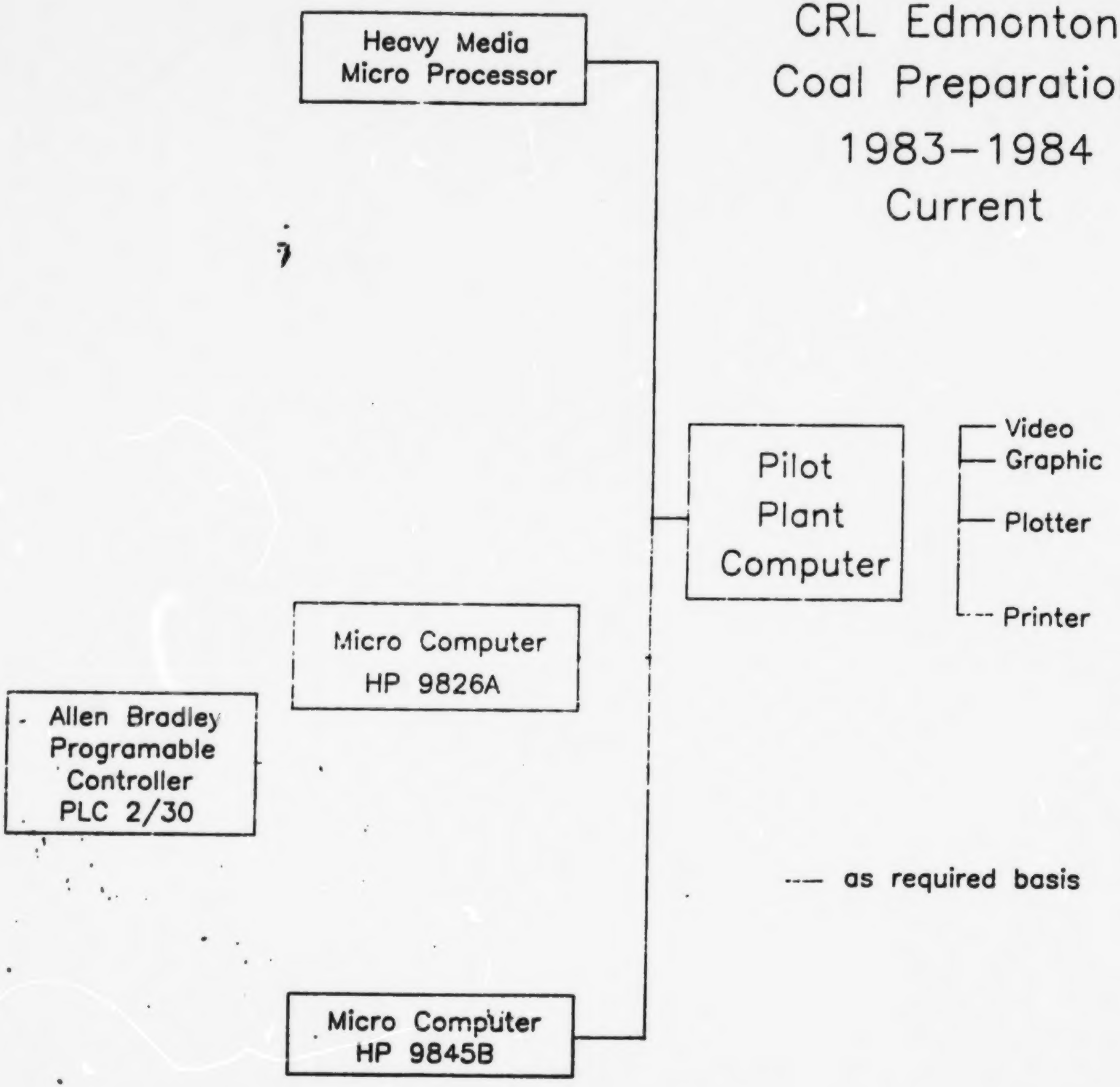
RAH/jr

APPENDIX 10

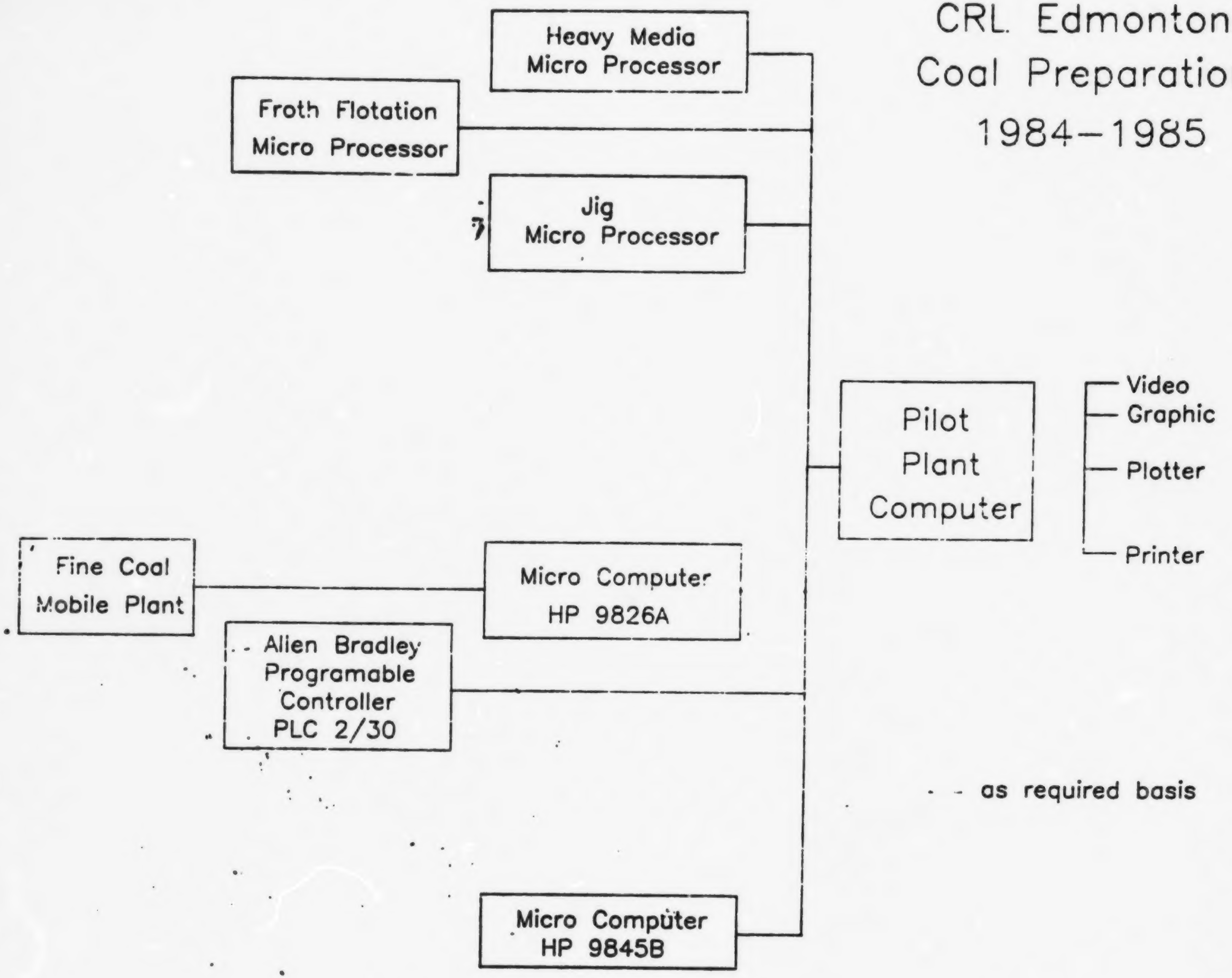
Originally Planned System Architecture

These diagrams were given to Cambrian during Phase I. This architecture has not been followed. See discussion in Section 5 of the report.

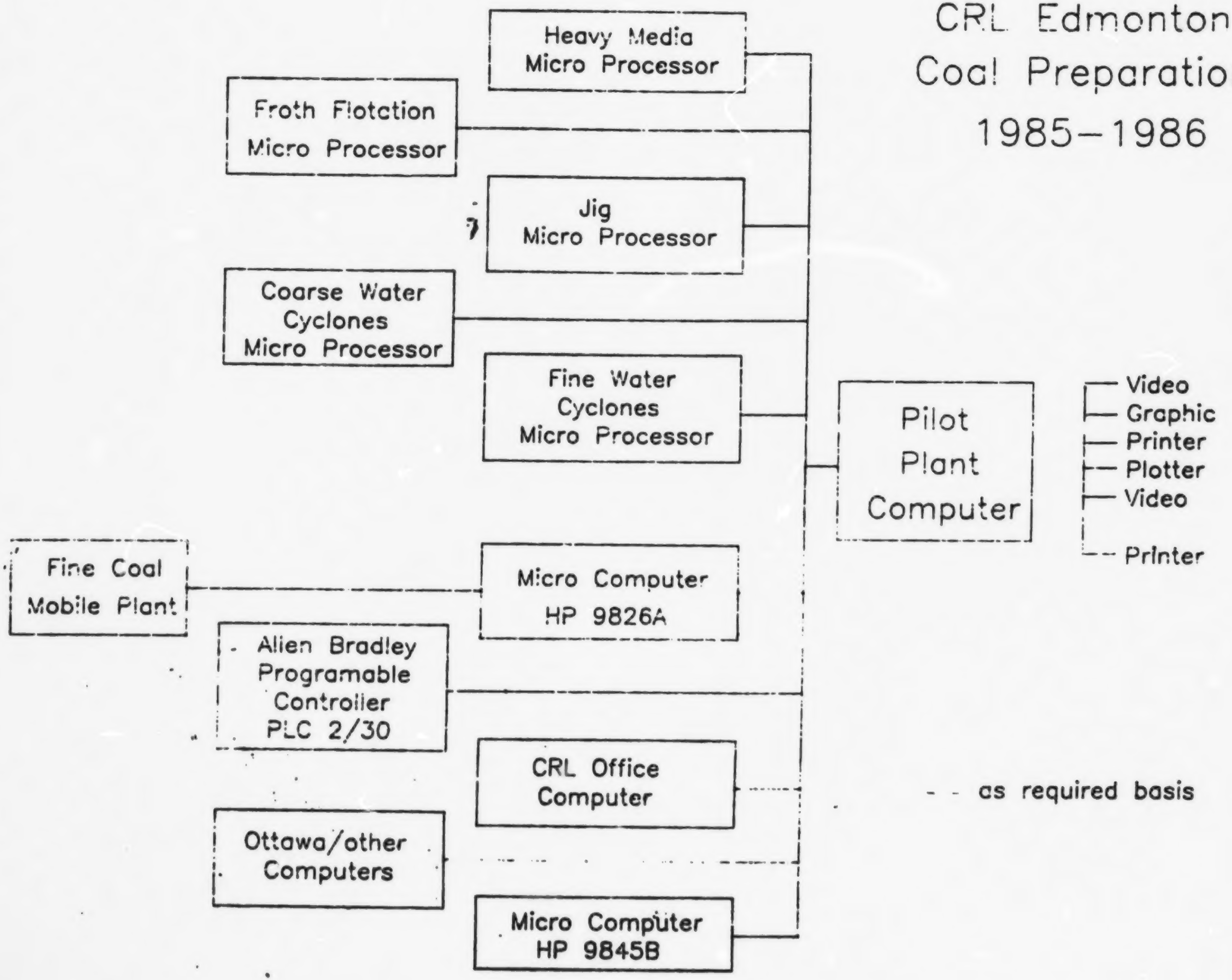
CRL Edmonton
Coal Preparation
1983–1984
Current


Heavy Media Micro Processor
Pilot Plant Computer
Video
Graphic
Plotter
Printer
Micro Computer HP 9826A
Allen Bradley Programable Controller PLC 2/30
Micro Computer HP 9845B
--- as required basis

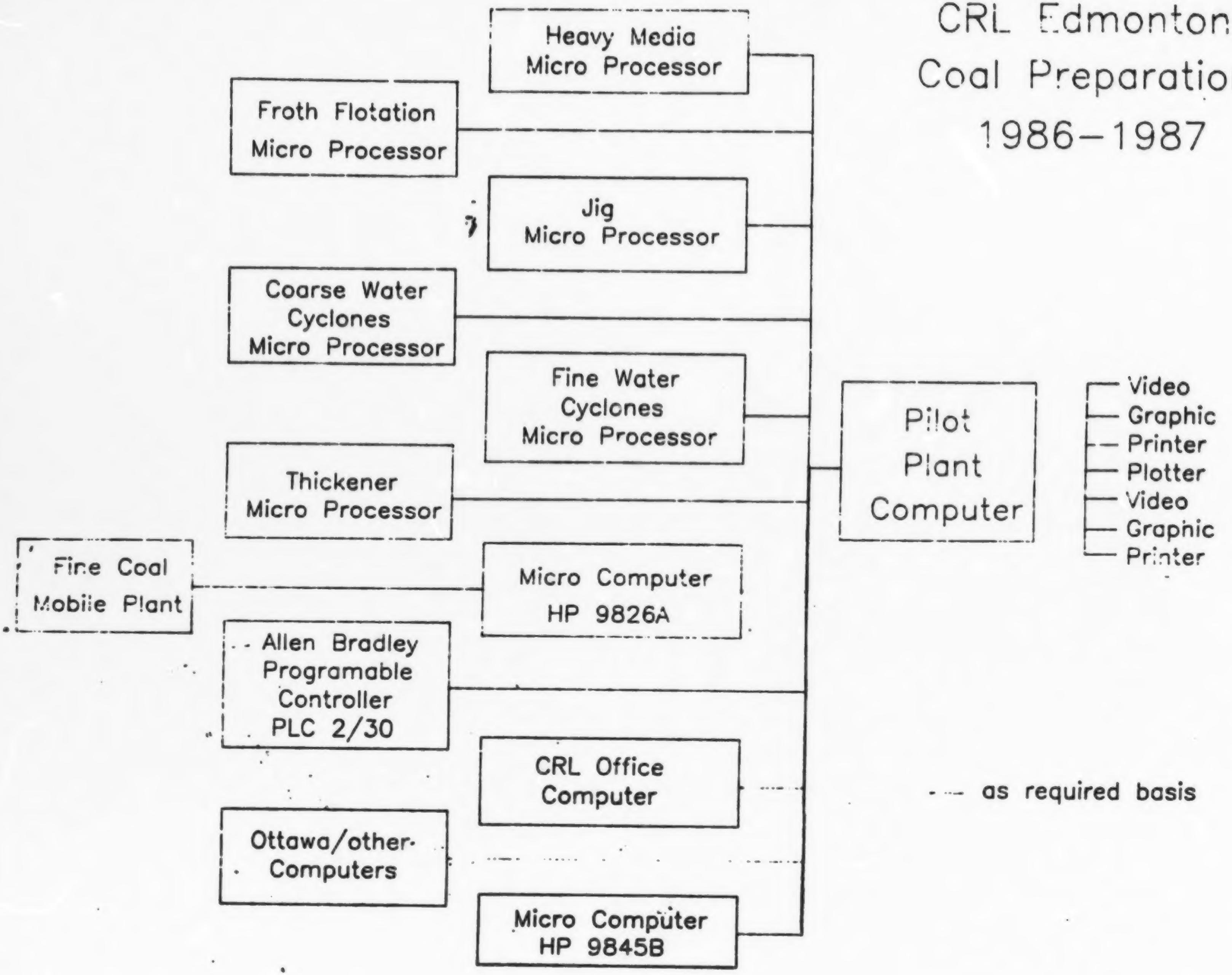
CRL Edmonton
Coal Preparation
1984–1985


Heavy Media Micro Processor
Froth Flotation Micro Processor
Jig Micro Processor
Pilot Plant Computer
Video
Graphic
Plotter
Printer
Fine Coal Mobile Plant
Micro Computer HP 9826A
Alien Bradley Programable Controller PLC 2/30
- - as required basis
Micro Computer HP 9845B

CRL Edmonton
Coal Preparation
1985–1986


Heavy Media Micro Processor
Froth Flotction Micro Processor
Jig Micro Processor
Coarse Water Cyclones Micro Processor
Fine Water Cyclones Micro Processor
Pilot Plant Computer
Video
Graphic
Printer
Plotter
Video
Printer
Fine Coal Mobile Plant
Micro Computer HP 9826A
Alien Bradley Programable Controller PLC 2/30
CRL Office Computer
Ottawa/other Computers
Micro Computer HP 9845B
- - as required basis

CRL Edmonton
Coal Preparation
1986–1987


Heavy Media Micro Processor
Froth Flotation Micro Processor
Jig Micro Processor
Coarse Water Cyclones Micro Processor
Fine Water Cyclones Micro Processor
Thickener Micro Processor
Fine Coal Mobile Plant
Micro Computer HP 9826A
Allen Bradley Programable Controller PLC 2/30
CRL Office Computer
Ottawa/other Computers
Micro Computer HP 9845B
Pilot Plant Computer
Video
Graphic
Printer
Plotter
Video
Graphic
Printer
as required basis

APPENDIX 11

Program Listings and Sample Results

APPENDIX 11

TABLE OF VARIABLE NAMES

These variable names are used in computer programs and on the P & ID:

For the Feed

FDF	Feed flow (liters/min)
FDMFS	Feed mass flow solids (kg/min)
FDSGU	Feed specific gravity units (of slurry)
CSGU	Carrier SGU
SSGU	Solids SGU (of solids in feed)
SVOL	Solids volume (liters/min)
FDWVOL	Feed water volume (liters/min)
FDMFW	Feed mass flow total (kg/min) (solids and water)
FDSR	Feed solids ratio (x 100 = % solids by volume)
FDASH	Feed ash fraction (x 100 = % ash)
FDMFC	Feed mass flow of coal (coal as 0% ash solids)

For the Tailings

TAF	Tailings flow (liters/min)
TASGU	Tailings SGU (of slurry)
TAASH	Tailings ash fraction (x 100 = % ash)
TASSGU	Tailings solids SGU
TASVOL	Tailings solids volume (liter/min)
TAMFS	Tailings mass flow of solids (kg/min)
TAWVOL	Tailings water volume (liters/min)
TAMFW	Tailings mass flow of water (kg/min)
TAMFT	Tailings mass flow total (kg/min)
TARS	Tailings rate of solids (x 100 = % solids)
TAMFC	Tailings mass flow of coal (coal as 0% ash solids)

APPENDIX 11

For the Product

PRMFS	Product mass flow of solids (kg/min)
PRGR	Product grade fraction (x 100 = % ash)
PRMFC	Product mass flow of coal (kg/min) (coal as 0% ash solids)
PRR	Product recovery fraction (x 100 = % of solids in feed which are recovered in product)
PRWVOL	Product water volume (liters/min)
PRSSGU	Product solids specific gravity units
PRMFW	Product mass flow water (kg/min)
PRSVOL	Product solids volume (liters/min)
PRF	Product flow (liters/min) (solids and water, no air)
PRMFT	Product mass flow total (kg/min) (solids and water)

```
FLOTATION SLURRY CASE NUMBER          1
SGU OF CARRIER             1
SGU OF SOLIDS              1.2

L/MIN        SLURRY       L/MIN        KG/MIN       L/MIN        %
TOTAL        SGU          SOLIDS       SOLIDS       CARRIER      SOLIDS

 100          1.02        9.99999       12           90           9.99999
 100          1.04        20            24           80           20
 100          1.06        30            36           70           30
 100          1.08        40            48           60           40
 100          1.1         50            60           50           50
MORE THAN 50 PERCENT SOLIDS, NOT A REASONABLE CASE.

FLOTATION SLURRY CASE NUMBER          2
SGU OF CARRIER             1
SGU OF SOLIDS              1.4

L/MIN        SLURRY       L/MIN        KG/MIN       L/MIN        %
TOTAL        SGU          SOLIDS       SOLIDS       CARRIER      SOLIDS

 100          1.02         4.99999     6.99999       95           4.99999
 100          1.04        9.99999      14            90           9.99999
 100          1.06        15           21            85           15
 100          1.08        20           28            80           20
 100          1.1         25           35            75           25

 300          1.02        15           21            285          4.99999
 300          1.04        30           42            270          9.99999
 300          1.06        44.9999      62.9999       255          15
 300          1.08        60           84            240          20
 300          1.1         75           105           225          25

 500          1.02        25           35            475          4.99999
 500          1.04        49.9999      69.9999       450          9.99999
 500          1.06        74.9999      105           425          15
 500          1.08        100          140           400          20
 500          1.1         125          175           375          25


FLOTATION SLURRY CASE NUMBER          3
SGU OF CARRIER             1
SGU OF SOLIDS              1.6

L/MIN        SLURRY       L/MIN        KG/MIN       L/MIN        %
TOTAL        SGU          SOLIDS       SOLIDS       CARRIER      SOLIDS
```

```
 100          1.02        3.33333      5.33333      96.6667      3.33333
 100          1.04        6.66666      10.6667      93.3333      6.66666
 100          1.06        9.99999      16           90           9.99999
 100          1.08        13.3333      21.3333      86.6667      13.3333
 100          1.1         16.6667      26.6667      83.3333      16.6667

 300          1.02        9.99999      16           290          3.33333
 300          1.04        20           32           280          6.66666
 300          1.06        30           47.9999      270          9.99999
 300          1.08        40           64           260          13.3333
 300          1.1         50           80           250          16.6667

 500          1.02        16.6666      26.6666      483.333      3.33333
 500          1.04        33.3333      53.3333      466.667      6.66666
 500          1.06        49.9999      79.9999      450          9.99999
 500          1.08        66.6667      106.667      433.333      13.3333
 500          1.1         83.3333      133.333      416.667      16.6667

FLOTATION SLURRY CASE NUMBER           4
SGU OF CARRIER              1
SGU OF SOLIDS               1.8

L/MIN         SLURRY      L/MIN        KG/MIN       L/MIN        %
TOTAL         SGU         SOLIDS       SOLIDS       CARRIER      SOLIDS

 100           1.02       2.5          4.5           97.5         2.5
 100           1.04       4.99999      8.99999       95           4.99999
 100           1.06       7.49999      13.5          92.5         7.49999
 100           1.08       10           18            90           10
 100           1.1        12.5         22.5          87.5         12.5

 300           1.02       7.49999      13.5          292.5        2.5
 300           1.04       15           27            285          4.99999
 300           1.06       22.5         40.5          277.5        7.49999
 300           1.08       30           54            270          10
 300           1.1        37.5         67.5          262.5        12.5

 500           1.02       12.5         22.5          487.5        2.5
 500           1.04       25           45            475          4.99999
 500           1.06       37.5         67.4999       462.5        7.49999
 500           1.08       50           90            450          10
 500           1.1        62.5         112.5         437.5        12.5
```

2

```
10:59:34      01/30/85


10 '   Program to print a table of slurry characteristics
20 OPEN "O",#1,"COM0:(28N20)"
30 PRINT#1,"A TABLE RELATING SLURRY CHARACTERISTICS":PRINT#1,""
40 '  The following two lines allow input of the maximum and minimun solids SGU
for the table.
50'INPUT"SGU OF CARRIER";CSGU
60 INPUT"MINIMUM SOLIDS SGU";SSGU
70 INPUT"MAXIMUM SOLIDS SGU";SSGUMA
80 C=1
90 PRINT#1,""
100 PRINT#1,"FLOTATION SLURRY CASE NUMBER ",C
110 PRINT#1,"SGU OF CARRIER",CSGU
120 PRINT#1,"SGU OF SOLIDS ",SSGU
130 PRINT#1,"":PRINT#1,"L/MIN","SLURRY","L/MIN","KG/MIN","L/MIN","%"
140 PRINT#1,"TOTAL","SGU","SOLIDS","SOLIDS","CARRIER","SOLIDS" :PRINT#1,""
150 '   The following line sets range and increment of feed flows for the table.
160 FOR FDF = 100 TO 500 STEP 200
170 '   The following line sets range and increment of slurry specific gravities
 for the table.
180 FOR FDSGUX = 102  TO 110 STEP 2
190 FDSGU = FDSGUX/100
200 SVOL = FDF*(FDSGU-CSGU)/(SSGU-CSGU)
210 FDMFS = SVOL * SSGU
220 CVOL = FDF-SVOL
230 FDRS = SVOL/FDF*100
240 PRINT#1,FDF,FDSGU,SVOL,FDMFS,CVOL,FDRS
250 IF FDRS >= 50  THEN PRINT#1,"MORE THAN 50 PERCENT SOLIDS, NOT A REASONABLE C
ASE.":GOTO 280
260 NEXT FDSGUX
270 PRINT#1,"":NEXT FDF
280 '   The following line sets the increment of solids SGU for the table.
290 C=C+1:SSGU=SSGU+.2:IFSSGU > SSGUMA THEN 310
300 GOTO 90
310 END
```

A

```
FROTH FLOTATION SIMULATION
MASS BALANCE CALCULATIONS

FEED CALCULATIONS

SOLIDS SGU                  1.62        CALCULATED FROM ASH SG RELATION
CARRIER SGU                 1           INPUT
FEED FLOW (L/MIN)           380         INPUT--MEASURED
FEED SGU                    1.03        INPUT--MEASURED
FLOW OF SOLIDS (L/MIN)      18.3871
MASS FLOW SOLIDS (KG/MIN)   29.7871
CARRIER FLOW (L/MIN)        361.613
MASS FLOW CARRIER (KG/MIN)  361.613
FEED MASS FLOW (KG/MIN)     391.4
% SOLIDS BY VOLUME          4.83871
FEED % ASH                  35          INPUT--MEASURED
MASS FLOW OF COAL (KG/MIN)  19.3616

PRODUCT REQUIREMENTS

DESIRED RECOVERY (%)        55          INPUT
DESIRED % ASH               9           INPUT
WATER FLOW (L/MIN)          54.2419     INPUT  ( 15  % OF FEED)
PRODUCT SOLIDS SGU          1.364       CALCULATED FROM ASH/SG RELATIONSHIP
MASS FLOW SOLIDS (KG/MIN)   16.3829
MASS FLOW OF COAL (KG/MIN)  14.9094

TO GET DESIRED PRODUCT TAILINGS MUST BE:

TAILINGS SOLIDS SGU         2.10222
TAILINGS FLOW (L/MIN)       313.747
CALCULATED TAILINGS SGU     1.0224
FLOW OF SOLIDS (L/MIN)      6.37619
MASS FLOW SOLIDS (KG/MIN)   13.4042
CARRIER FLOW (L/MIN)        307.371
MASS FLOW CARRIER (KG/MIN)  307.371
TAILINGS MASS FLOW (KG/MIN) 320.775
% SOLIDS BY VOLUME          2.03227
MASS FLOW OF COAL (KG/MIN)  4.45317
TAILINGS ASH (%)            66.7778
WITH THIS ASH THE SOLIDS SG FROM TABLE IS 1.96456
 CHECK WITH VALUE PRINTED ABOVE
```

```
TAILINGS CALCULATIONS FOR KNOWN TAILINGS

TAILINGS % ASH                 66.7778      INPUT--MEASURED
TAILINGS FLOW (L/MIN)          313.747      INPUT--MEASURED
MEASURED TAILINGS SGU          1.0224       INPUT--MEASURED
TAILINGS SOLIDS SGU            2.10222      INPUT
FLOW OF SOLIDS (L/MIN)         6.3762
MASS FLOW SOLIDS (KG/MIN)      13.4042
CARRIER FLOW (L/MIN)           307.371
MASS FLOW CARRIER (KG/HR)      307.371
TAILINGS MASS FLOW (KG/MIN)    320.775
% SOLIDS BY VOLUME             2.03227
MASS FLOW OF COAL (KG/MIN)     4.45316

PRODUCT CALCULATIONS FOR KNOWN TAILINGS

PRODUCT RECOVERY % OF FEED     55
PRODUCT GRADE % ASH            8.99998
WATER FLOW (L/MIN)             54.2421
MASS FLOW SOLIDS (KG/MIN)      16.3829
MASS FLOW COAL (KG/MIN)        14.9084

THE TEN DATA POINTS FOR ASH TO SOLIDS SG RELATION ARE:
 1              0              1.25
 2              5              1.3
 3              10             1.38
 4              15             1.4
 5              20             1.47
 6              30             1.56
 7              40             1.68
 8              50             1.79
 9              60             1.89
 10             70             2

RUN COMPLETED 09:01:14      02/08/85
```

B

```
09:01:36      02/08/85


10 '   MASS BALANCE CALCULATIONS
20 '   VERSION 1.4 JAN 16,1985
30 SCROLL 9
40 WIDTH 20,20
50 INPUT "SELECT OUTPUT DEVICE S MP or P";A$
60 IF A$="S" THEN100
70 IF A$="MP"THEN110
80 IF A$="P"THEN120:GOTO 50
90 GOTO 50
100 OPEN"O",#1,"SCRN:":GOTO 130
110 OPEN"O",#1,"LPT0:":GOTO 130
120 OPEN"O",#1,"COM0:(28N20)":GOTO 130
130 PRINT#1,"FROTH FLOTATION SIMULATION":PRINT#1,"MASS BALANCE CALCULATIONS":PRI
NT#1,""
140 PRINT#1,"FEED CALCULATIONS":PRINT#1,""
150 '   FEED CALCULATIONS
160 '
170 '   ASH TO SOLIDS SG RELATIONSHIP
180 DIM AGR(2,10)
190 FOR B=1TO10 :FORA=1TO2 :READ AGR(A,B):NEXT:NEXT
200 INPUT"MEASURED FEED ASH %";FDASH1:FDASH=FDASH1/100
210 FL= 1:GOSUB1610
220 INPUT"CARRIER SGU";CSGU
230 INPUT"FEED FLOW (L/MIN)";FDF
240 INPUT"FEED SGU";FDSGU
250 PRINT#1,"SOLIDS SGU",,SSGU,"CALCULATED FROM ASH SG RELATION"
260 PRINT#1,"CARRIER SGU",,CSGU,"INPUT"
270 PRINT#1,"FEED FLOW (L/MIN)",FDF,"INPUT--MEASURED"
280 PRINT#1,"FEED SGU",,FDSGU,"INPUT--MEASURED"
290 SVOL=FDF*(FDSGU-CSGU)/(SSGU-CSGU)
300 PRINT#1,"FLOW OF SOLIDS (L/MIN)",SVOL
310 FDMFS=SVOL*SSGU
320 PRINT#1,"MASS FLOW SOLIDS (KG/MIN)",FDMFS
330 FDWVOL=FDF-SVOL
340 PRINT#1,"CARRIER FLOW (L/MIN)",FDWVOL
350 FDMFW = FDWVOL*CSGU
360 PRINT#1,"MASS FLOW CARRIER (KG/MIN)",FDMFW
370 FDMFT=FDF*FDSGU
380 PRINT#1,"FEED MASS FLOW (KG/MIN)",FDMFT
390 FDSR=SVOL/FDF
400 PRINT#1,"% SOLIDS BY VOLUME",FDSR*100
410 '   DATA FROM ASH MONITOR
420 '
```

```
430 FDMFC=(1-FDASH)*FDMFS
440 PRINT#1,"FEED % ASH",,FDASH1,"INPUT--MEASURED"
450 PRINT#1,"MASS FLOW OF COAL (KG/MIN)",FDMFC
460 CLS:PRINT "CHOOSE A or B
470 PRINT"A) KNOWN TAILINGS":PRINT"B) DESIRED PRODUCT"
480 A$=INPUT$(1):IF A$="A"THEN 510
490 IF A$="B"THEN 1030
500 GOTO 460
510 '   TAILINGS CALCULATIONS FOR KNOWN TAILINGS
520 '
530 SCROLL 5
540 PRINT#1,"":PRINT#1,"TAILINGS CALCULATIONS FOR KNOWN TAILINGS":PRINT#1,""
550 INPUT "TAILINGS FLOW (L/MIN)";TAF
560 IF TAF<FDF THEN 580
570 SOUND15,5:PRINT"TAILINGS FLOW MUST BE LESS THAN FEED FLOW":GOTO 550
580 INPUT "TAILINGS SGU";TASGU
590 IF TASGU<FDMFT/TAF THEN 610
600 SOUND15,5:PRINT "TAILINGS MASS FLOW MUST BE LESS THAN FEED MASS FLOW":GOTO 5
50
610 INPUT"MEASURED TAILINGS ASH %";TAASH!:TAASH=TAASH!/100
612 INPUT"DO YOU WISH TO INPUT TAILINGS SOLIDS SGU (Y/N)";Q$
614 IF Q$="N"THEN 620
615 IF Q$<>"Y"THEN 612
616 INPUT"TAILINGS SOLIDS SGU";TSSGU:GOTO 640
620 FDASH! = TAASH!:FL=2:GOSUB 1610
630 TSSGU = SSGU
640 TASVOL=TAF*(TASGU-CSGU)/(TSSGU-CSGU)
650 TAMFS=TASVOL*TSSGU
660 IF TAMFS<FDMFS THEN 680
670 SOUND15,5:PRINT "TAILINGS MASS FLOW OF SOLIDS MUST BE LESS THAN FEED MASS FL
OW OF SOLIDS":GOTO 550
680 TAWVOL=TAF-TASVOL
690 TAMFW=TAWVOL*CSGU
700 TAMFT=TAF*TASGU
710 TARS = TASVOL/TAF
720 '   FROM ASH MONITOR
730 '
740 TAMFC=(1-TAASH)*TAMFS
750 IF TAMFC<FDMFC THEN 770
760 SOUND15,5:PRINT"TAILINGS MASS FLOW OF COAL MUST BE LESS THAN FEED MASS FLOW
OF COAL":GOTO 610
770 IF TAMFS-TAMFC<FDMFS-FDMFC THEN 790
780 SOUND15,5:PRINT "TAILINGS MASS FLOW OF ASH MUST BE LESS THAN FEED MASS FLOW
OF ASH":GOTO 610
```

D

```
790 PRINT#1,"TAILINGS % ASH",TAASH1,"INPUT--MEASURED"
800 PRINT#1,"TAILINGS FLOW (L/MIN)",TAF,"INPUT--MEASURED"
810 PRINT#1,"MEASURED TAILINGS SGU",TASGU,"INPUT--MEASURED"
815 IF Q$="Y"THEN PRINT#1,"TAILINGS SOLIDS SGU",TSSGU,"INPUT":GOTO 830
820 PRINT#1,"TAILINGS SOLIDS SGU",TSSGU,"CALCULATED FROM ASH/SG RELATIONSHIP"
830 PRINT#1,"FLOW OF SOLIDS (L/MIN)",TASVOL
840 PRINT#1,"MASS FLOW SOLIDS (KG/MIN)",TAMFS
850 PRINT#1,"CARRIER FLOW (L/MIN)",TAWVOL
860 PRINT#1,"MASS FLOW CARRIER (KG/HR)",TAMFW
870 PRINT#1,"TAILINGS MASS FLOW (KG/MIN)",TAMFT
880 PRINT#1,"% SOLIDS BY VOLUME",TARS*100
890 PRINT#1,"MASS FLOW OF COAL (KG/MIN)",TAMFC
900 '   PRODUCT CALCULATIONS FOR KNOWN TAILINGS
910 '
920 PRINT#1,"":PRINT#1,"PRODUCT CALCULATIONS FOR KNOWN TAILINGS":PRINT#1,""
930 PRMFS=FDMFS-TAMFS
940 PRGR = ((FDMFS-FDMFC)-(TAMFS-TAMFC))/(FDMFS-TAMFS)
950 PRMFC = PRMFS*(1-PRGR)
960 PRR = (FDMFS-TAMFS)/FDMFS
970 PRINT#1,"PRODUCT RECOVERY % OF FEED",PRR*100
980 PRINT#1,"PRODUCT GRADE % ASH",PRGR*100
990 PRWVOL=FDWVOL-TAWVOL:PRINT#1,"WATER FLOW (L/MIN)",PRWVOL
1000 PRINT#1,"MASS FLOW SOLIDS (KG/MIN)",PRMFS
1010 PRINT#1,"MASS FLOW COAL (KG/MIN)",PRMFC
1020 GOTO 1460
1030 '   CALCULATE TAILINGS SPEC REQUIRED TO GET A DESIRED PRODUCT
1040 '   CALCS FOR DESIRED PRODUCT
1050 INPUT "DESIRED % RECOVERY";PRR1:PRR=PRR1/100
1060 INPUT "DESIRED % ASH";PRGR1:PRGR=PRGR1/100
1070 INPUT "% OF FEED WATER IN PRODUCT";X:PRWVOL=FDWVOL*X/100
1080 FDASH1=PRGR1:FL=3:GOSUB1610
1090 PRSSGU=SSGU
1100 PRINT#1,"":PRINT#1,"PRODUCT REQUIREMENTS",CHR$(10)
1110 PRINT#1,"DESIRED RECOVERY (%)",PRR1,"INPUT"
1120 PRINT#1,"DESIRED % ASH",,PRGR1,"INPUT"
1130 PRMFW = PRWVOL*CSGU
1140 PRMFS = PRR*FDMFS
1150 PRMFC = (1-PRGR)*PRMFS
1160 PRSVOL = PRMFS/PRSSGU
1170 PRF = PRWVOL+PRSVOL
1180 PRMFT = PRMFW+PRMFS
1190 PRINT#1,"WATER FLOW (L/MIN)",PRWVOL,"INPUT  (";X;" % OF FEED)"
1200 PRINT#1,"PRODUCT SOLIDS SGU",PRSSGU,"CALCULATED FROM ASH/SG RELATIONSHIP"
1210 PRINT#1,"MASS FLOW SOLIDS (KG/MIN)",PRMFS
1220 PRINT#1,"MASS FLOW OF COAL (KG/MIN)",PRMFC
1230 '   TAILINGS CALCULATIONS FOR DESIRED PRODUCT
1240 '
```

E

```
1250 TAMFS = FDMFS-PRMFS
1260 TAMFW = FDMFW-PRMFW:TAMFT=TAMFW+TAMFS
1270 TAWVOL = TAMFW/CSGU
1280 TAF=FDF-PRF:TASVOL=TAF-TAWVOL:TSSGU=TAMFS/TASVOL
1290 TASGU = (TAMFS+TAMFW)/TAF
1300 PRINT#1,"":PRINT#1,"TO GET DESIRED PRODUCT TAILINGS MUST BE:":PRINT#1,""
1310 PRINT#1,"TAILINGS SOLIDS SGU",TSSGU
1320 PRINT#1,"TAILINGS FLOW (L/MIN)",TAF
1330 PRINT#1,"CALCULATED TAILINGS SGU",TASGU
1340 PRINT#1,"FLOW OF SOLIDS (L/MIN)",TASVOL
1350 PRINT#1,"MASS FLOW SOLIDS (KG/MIN)",TAMFS
1360 PRINT#1,"CARRIER FLOW (L/MIN)",TAWVOL
1370 PRINT#1,"MASS FLOW CARRIER (KG/MIN)",TAMFW
1380 PRINT#1,"TAILINGS MASS FLOW (KG/MIN)",TAMFT
1390 TARS = TASVOL/TAF:PRINT#1,"% SOLIDS BY VOLUME",TARS*100
1400 TAMFC = FDMFC-PRMFC:TAASH = 1-(TAMFC/TAMFS)
1405 PRINT#1,"MASS FLOW OF COAL (KG/MIN)",TAMFC
1410 PRINT#1,"TAILINGS ASH (%)",TAASH*100
1420 '   CHECKING CALCULATED ASH AND TSSGU AGAINST ASH/SG TABLE
1430 FDASH1=TAASH*100:FL=4:GOSUB 1610
1440 PRINT#1,"WITH THIS ASH THE SOLIDS SG FROM TABLE IS";SSGU;" CHECK WITH VALUE
 PRINTED ABOVE"
1450 '   LOGIC TO CONTINUE OR TO END
1460 CLS: PRINT "CHOOSE A OR B":PRINT "A) CONTINUE":PRINT "B) END"
1470 A$ = INPUT$(1):IF A$="B" THEN 1540
1480 IF A$="A" THEN 1500
1490 GOTO 1460
1500 CLS:PRINT"CHOOSE A OR B":PRINT"A) NEW PRODUCT":PRINT"B) NEW TAILINGS"
1510 A$=INPUT$(1):IF A$ = "A" THEN 1030
1520 IF A$ ="B" THEN 510
1530 GOTO 1500
1540 PRINT#1,"":PRINT#1,"THE TEN DATA POINTS FOR ASH TO SOLIDS SG RELATION ARE:"
1550 FOR B=1 TO 10:PRINT#1,B,AGR(1,B),AGR(2,B):NEXT B
1560 PRINT#1,"":PRINT#1,"RUN COMPLETED",TIME$,DATE$:SOUND15,5:SOUND20,5
1570 CLOSE
1580 END
1590 '   DATA FOR ASH/SOLIDS SG RELATION
1600 DATA 0,1.25,5,1.30,10,1.38,15,1.40,20,1.47,30,1.56,40,1.68,50,1.79,60,1.89,
70,2.00
1610 '   SUBROUTINE FOR FINDING SOLIDS SG (SSGU) FROM ASH VALUE
1620 C=1
1630 IF C>10 THEN SOUND 15,5:PRINT"ASH VALUE NOT IN    RANGE TRY AGAIN":ON FL GO
TO 200,610,1050,1450
1640 IF FDASH1<=AGR(1,C) THEN 1660
```

F

```
1650 C-C+1:GOTO 1630
1660 IF C-1 THEN C-11:GOTO 1630
1670 SSGU =(FDASH1-AGR(1,C-1))/(AGR(1,C)-AGR(1,C-1))*(AGR(2,C)-AGR(2,C-1))+AGR(2
,C-1)
1680 RETURN
```

APPENDIX 12

Full Size Drawing Prints